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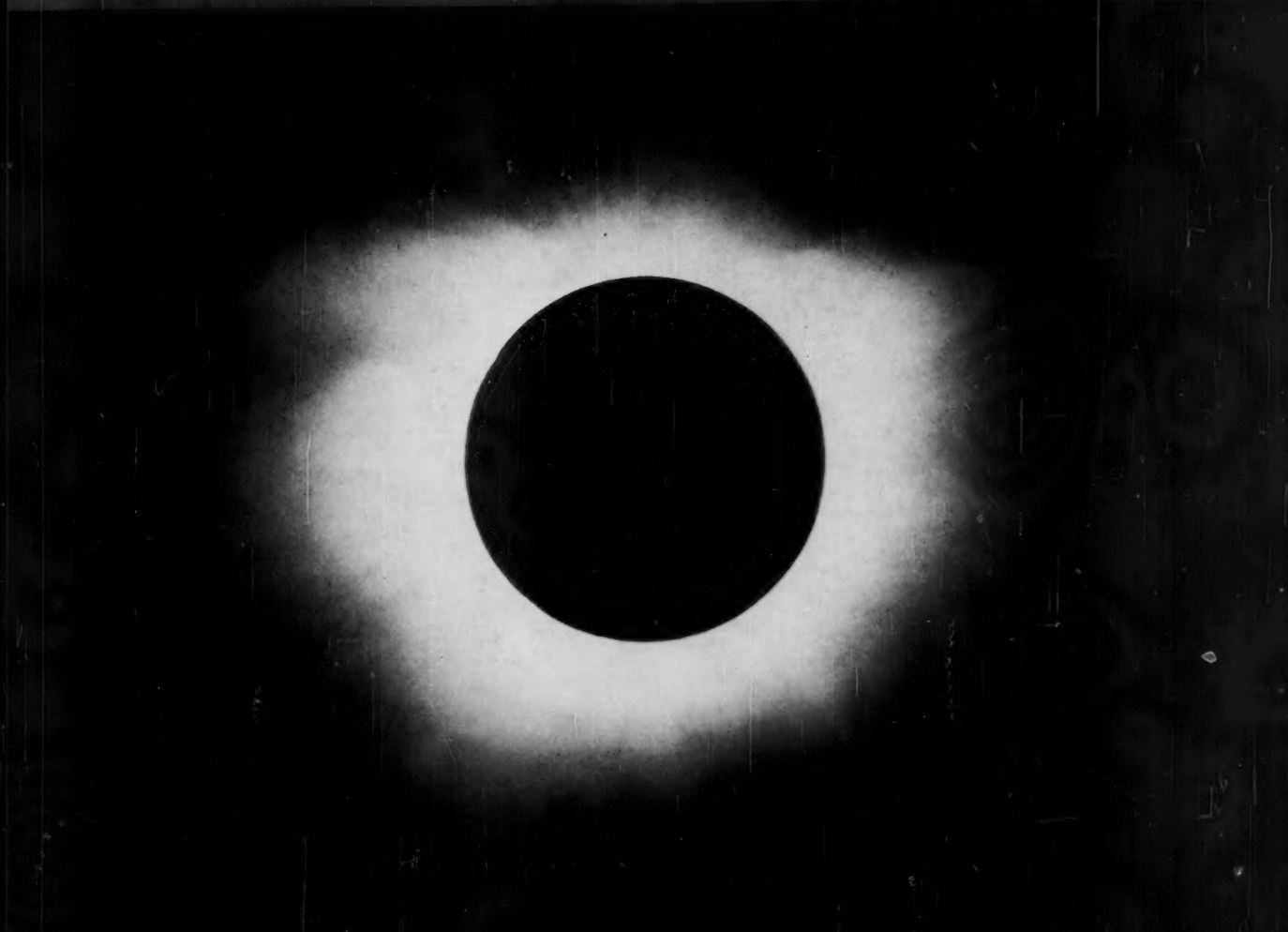

February's total solar eclipse

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APRIL, 1961
50 cents

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American Astronomers Report
Stars for April

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Sky and TELESCOPE

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Vol. XXI, No. 4 APRIL, 1961

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A Magnificent Eclipse

"TRACKS of total eclipses delight in crossing the broad Pacific, rarely touching land except at some small island of difficult access. At least so it seems to astronomers who are interested in following most solar eclipses professionally.

"The eclipse of February 15, 1961, on the contrary, covered a band of extremely high population density. And since the weather was clear over a large portion of this area, the total phase may have been observed by more people than any other eclipse in history.

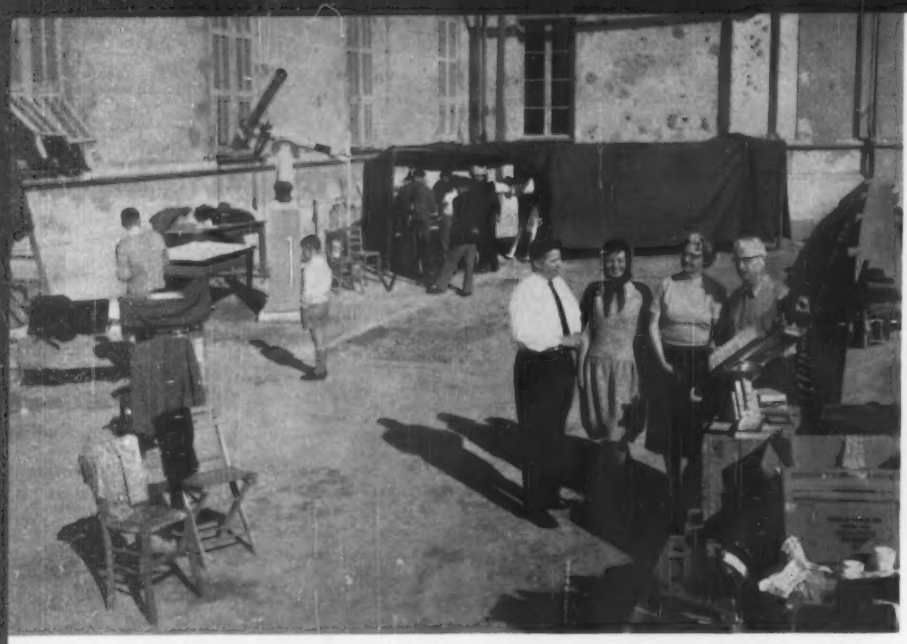
"As I enjoyed the food and living quarters in our hotel at San Remo, Italy, I could not help but consider the advantages of having an eclipse in a country like that rather than at Pukapuka (October 12, 1958), the Siberian steppes (June 19, 1936), or even Bredenbury, Saskatchewan (July 9, 1945). The U. S. Navy took astronomers to the Danger Islands for the first of these; at Ak-Bulak in Kazakhstan, I lived in a tent and relied on a camel for transportation; and even in western Canada I had to walk half a mile to the railroad roundhouse to get a warm bath."

These are the words of Donald H. Menzel, director of Harvard Observatory and correspondent for SKY AND TELESCOPE covering the February eclipse at Imperia and other places in Italy. His firsthand account appears in this issue, along with a number of reports from other groups that were successful in observing and photographing the corona of the sun that day.

Dr. Menzel notes that television coverage was excellent, and almost everyone in Europe could view the eclipse in one way or another. It was Galileo's birthday, and a 45-minute television program reviewed his contributions and those of other Italian and European scientists toward our present understanding of the sun.

But not all those who studied this event observed it from Europe and Asia. A note from a radio enthusiast, David F. Thomas of Proctorville, Ohio, reports his observations of certain changes in radio reception from European stations that were located in or near the path of totality (see page 204).

One issue of this magazine can contain only a limited selection of the expedition pictures and eclipse photographs received from abroad or brought back by Dr. Menzel. Publication of some excellent observations must therefore be postponed until May. Meanwhile, special thanks are due to all persons and institutions who have sent us material or furnished it to our eclipse correspondents here and abroad.



Far in the background of this school courtyard scene at Imperia, Italy, is the long shelter for the 5½-inch horizontal camera of Monte Mario Observatory. Left of it is the 4.3-inch coronagraph, with part of the French group's equipment at the extreme left. In the right foreground are G. E. Moreton (white shirt), Mrs. Geraldine Crosswell, Mrs. and Dr. D. H. Menzel. The women operated the 2½-inch apochromat, with equatorial mounting, that is set on the parapet in front of the author. He photographed all terrestrial scenes in this article with a Polaroid Land camera.

Eclipse Over the Mediterranean

DONALD H. MENZEL

Harvard College Observatory

JUST A FEW DAYS remain until the total solar eclipse of February 15th, as I begin this account in the town of Imperia, on the Italian Riviera. Astronomers from many countries have come here, at the invitation of Prof. Massimo Ciminó, director of Rome's Monte Mario Observatory.

My writing station is a balcony or rather a high terrace on the eastern side of the local school: a combined elementary, high, and technical school with an associated meteorological observatory. The students have received two days' vacation in celebration of the coming eclipse. The terrace before me is a scene of bustling activity as the astronomers adjust, check, test, and recheck their instruments. Many of them are practicing their eclipse routine, so that the moment of totality will not catch them unprepared.

The most extensive observing program here is Professor Cimino's. His principal assistants are Miss Maria Torelli and Miss Teresa Fortini of his staff at Monte Mario, the engineer Romeo Flamini, and Francesco Cassamassima. Their largest instrument is housed under the shelter seen in the corner of the terrace. It is a horizontal camera 5½ inches in aperture and 16 feet in focal length. The coelostat's 12-inch mirror directs sunlight into the objective. Used with a yellow-orange filter, this camera will photograph the inner and medium regions of the sun's corona.

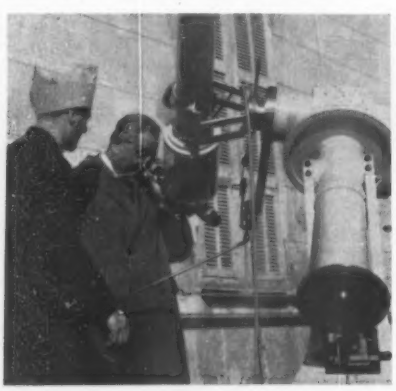
The Roman astronomers' second instrument is a coronagraph, the primary telescope having a 4.3-inch, f/17 objective. It passes light through a Lyot hydrogen-alpha filter made by Halle, with a passband of 0.5 angstrom. The arrangement is particularly designed to show the chromosphere, prominences, and the corona in the continuous spectrum near $H\alpha$.

This same terrace is the observing site of a French expedition, planned by Adouin Dollfus of the Meudon Observatory near Paris. He remained home, however, because his wife expects a child on or about eclipse day. Two members of his staff, Maurice Marin and Jean-Louis Hemeret, are here in Imperia. They hope to measure light intensities in different parts of the corona by means of photographic photometry. As seen in the picture of their equipment, a small coelostat feeds light into a horizontal reflector of 4½ feet focal length. Dr. Dollfus' plans call for simultaneous visual observations of the inner corona's brightness with a coronagraph *outside* the path of totality, to compare with the records obtained here.

A third expedition to Imperia is that of the well-known Swedish solar astronomer Yngve Ohman, of Stockholm Observatory and Sweden's national observatory on the Isle of Capri. He is to photograph the infrared spectrum of the prominences and solar corona with an ingenious compact device. Its diffraction grating is mounted as a coelostat, turning by clockwork to compensate for the apparent motion of the sun. The polar axis of this instrument rotates once in 48 hours, because the reflected image travels twice as fast as the sun does. Professor Ohman sets up a 35-mm. camera in the right position to photograph the first-order infrared spectrum formed by the grating.

The meteorological and seismological observatory at Imperia plans to use a 5½-inch f/11 refractor and exposures of one second to record the corona.

Our Harvard expedition is a relatively modest one, since the decision to send it



In these close-ups of the Roman expedition's equipment, Massimo Cimino looks through the 4.3-inch telescope at the left, while Romeo Flamini examines the controls of the 12-inch coelostat at the right. Supported by the bricks is the 5½-inch objective of the horizontal camera, which gave an image of the sun about 1¾ inches in diameter.

On the round coelostat mirror of Yngve Ohman's apparatus can be seen the rectangular ruled area of the diffraction grating. With this simple device, the Swedish astronomer obtained an infrared spectrum of the sun's prominences and inner corona.

was made only at the last minute. The chances of fair weather seemed so poor that none of the American observatories traditionally dedicated to eclipse studies decided to send an expedition. However, an invitation to participate in the Rome symposium on solar seeing, following the eclipse, caused me to reverse an earlier decision and to put together what equipment I could in a short time.

We remembered that at the New England eclipse of October 2, 1959, Dr. E. H. Land, inventor of the Polaroid Land camera, had accompanied Harvard astronomers on a DC-6 plane that flew above the heavy overcast. On this flight, Dr. Land and his colleagues secured several excellent photographs of the corona, using Polaroid cameras with telephoto lenses. The recently invented high-speed film, with a sensitivity rating of ASA 3,000, gave the pictures great sharpness. Since then, the development time for this film has been lowered from one minute to 10 seconds, greatly increasing its potentialities for eclipse work.

The author rehearses his routine with one of the special Polaroid cameras.

Dr. Land lent us the two cameras he had built for the 1959 eclipse. Each is fitted with large binoculars, the right-hand half sending parallel light into the camera lens, the left-hand part serving for pointing on the sun.

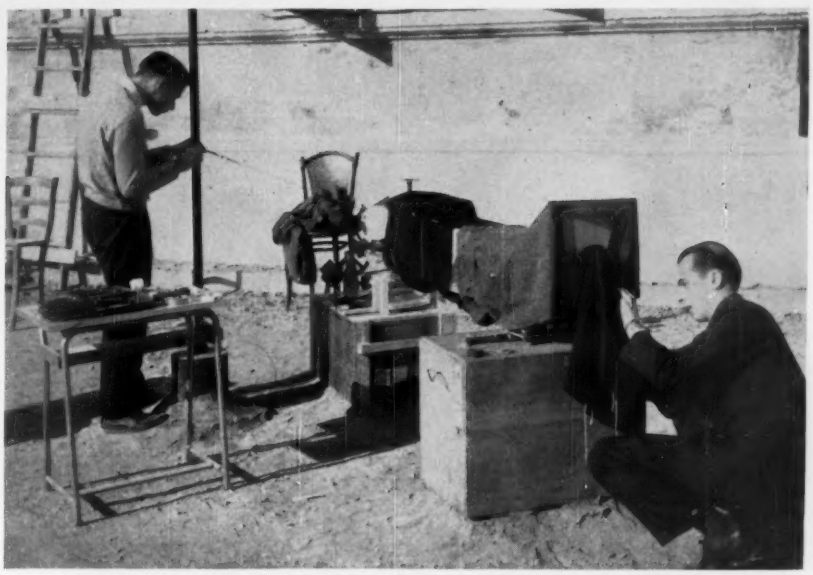
At Imperia, one of these Land cameras will be used for direct coronal photography. G. E. Moreton, director of Lockheed Solar Observatory, who has joined our party two days before totality, will operate it. I am to use the other camera for a series of corona exposures through a polaroid filter that can be rotated in front of the objective lens. Each camera is being supported on the balustrade surrounding the terrace, upon a heavy box wedged to obtain the proper direction. During the two minutes of totality, no repointing of the cameras will be needed.

Already we have made exposure tests on the full moon, which has about the same brightness as the corona. Further tests made today have led us to revise the picture schedule. Instead of Mr. Moreton taking only one roll of eight corona pictures during totality, it now seems safe to try two rolls, by having an assistant remove the finished pictures from the first roll while the observer is exposing the second.

Our party has a third photographic instrument, using a new experimental Polaroid film with unusual characteristics that might make it especially effective for recording the corona. This camera, which has a 2½-inch apochromatic lens of 40 inches focal length, was designed by Hector Ingrao and built by Lionel Caron at Harvard Observatory. Lightweight construction was necessary, because the over-all weight of our eclipse equipment was limited to 175 pounds. Mrs. Menzel and Mrs. Geraldine Crosswell are in charge of this instrument.

The day of February 14th is now drawing to a close. So far, the weather has been better than anyone expected, with no rain at all, and with most mornings reasonably clear at eclipse time. But we are having some unforeseen difficulties.

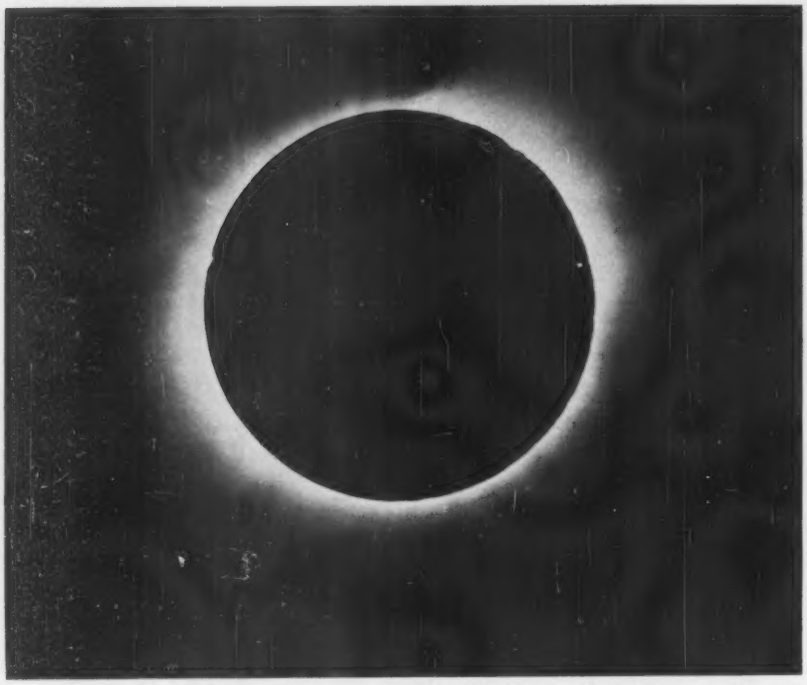
On the morning of the 13th, when we were leaving the hotel early to test the instruments at the time of eclipse, I couldn't find my shoes and had to go out wearing only light slippers. The efficient maid had removed them for cleaning, never expecting that any hotel guest would rise at such an unearthly hour. That evening I hid the shoes in the bottom of the clothes closet, but the next morning again no shoes! Now at night I put them in the lockbox with money and other valuables, so as to be properly clothed for the eclipse.



In typical eclipse expedition fashion, the astronomers from Meudon Observatory bring equipment that is easy to set up, operate, and dismantle.

When we arrived here, our observing equipment was locked up where we could not get at it. We have a key to the courtyard gate, but not to the storage room. Yet we must be ready for dawn practice until the operation of our coronal cameras becomes almost automatic. It is important to go through the routine while the sky is still dark, for dim twilight resembles the light during totality.

Professor Cimino has had the foresight to obtain an order from the Imperia city council banning the building of fires until after the eclipse. The people have co-operated extremely well, and certainly part of the sky's clarity is due to this precaution. In fact, the people in general seem thoroughly informed as to what is going on. The newspapers have warned



During totality, the dark disk of the moon hides the sun's dazzling photosphere, permitting photography of the solar corona. Its inner parts are recorded in this short exposure with the Rome 5½-inch horizontal telescope.

them to use dark glasses or fogged film for observing the partial phase. We have just learned of the Soviet Venus probe, which has increased the local interest in astronomy.

Eclipse day has begun. I am now dictating from the plaza at Imperia at 5 o'clock in the morning. None of us slept very much. We kept bouncing up to see whether the storm that we had heard reported last night was likely to move in from Spain. But the static high-pressure region around us has effectively screened it off, and the sky is at present beautifully clear. Some low-lying clouds streak the east, however, and it is too early to predict. Partial eclipse will begin at 7:28 a.m., totality at 8:33.

This morning is cold and wet — the heaviest fall of dew I have ever seen anywhere. It is condensing on everything, on the tables, walls, and ground. It drips from the trees and rafters, and I dare not sit down to dictate. What will this do to our instruments? But first of all we need to get them, and still have no key to the storage room. There! We have found an open window, and in 10 minutes our equipment can be set up. We cover it with blankets and raincoats, but the dew continues to drip.

A few minutes later the French astronomers arrive, and finally the Italians. We do not explain how we got our instruments.

There is still one thing missing. The heavy bricks we ordered for our camera mountings, and which were promised without fail, have not arrived. Fortunately, in the predawn darkness we have located a building under construction, and soon have borrowed all the bricks we need. The cameras are ready, and now we hold our last rehearsal.

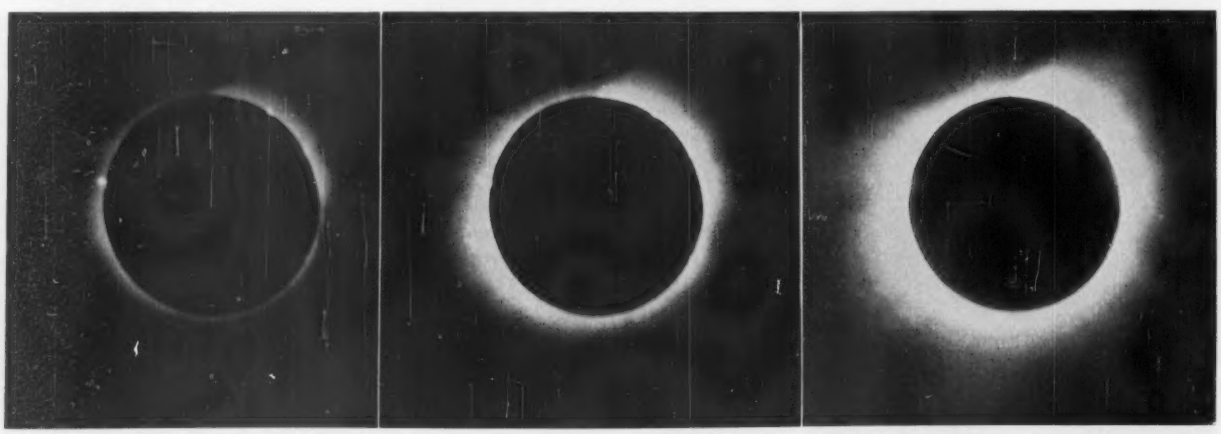
Immediately afterward, I find the instruments, and their lenses, are dripping with moisture. We dry and cover them, and decide on two minor changes of schedule because of the dew. We will not load the cameras until the last minute nor will we open the film packages until two or three minutes before totality.

The eastern sky is bright now, and I can hear people moving in the street below. They are gathering in the market square outside of the school, as near to the scientists as possible. Yesterday, our preparations were seriously hampered by local visitors.

The rising sun is a red ball through the threatening horizon mists. And there is a small bite on its edge — first contact has already taken place! We watch the sun rise into clearer sky, and now we feel convinced, long before totality, that we will see that event. We unwrap the instruments and get them pointed to the sun.

There is always something awe-inspiring about a total eclipse, and I can readily see how it could frighten anyone ignorant of its cause. About 10 minutes before totality the horizon shows a yellowish hue and all objects take on an unnatural color. The darkness is deepening rapidly, and I turn to look at the white sheet someone has hung against the wall of the school. In most eclipses, one can see shadow bands crossing such a surface. These are caused by irregularities in the earth's atmosphere. Happy indeed is the astronomer who does not see them, for he can conclude that the air is steady and poor seeing will not interfere with his observations and distort the sun.

Events pile in on us now. Just before



Some astronomers from Rome employed a camera of 36-inch focus in a jet plane flying 40,000 feet high, this series having been enlarged about four times from the negatives. The shortest exposure, at the left, shows the inner corona and some prominences, but these are burned out in the longer exposures of the middle and outer parts of the corona.

A view of corona structure very nearly like that seen by the eye of an observer is achieved in this unusual picture. As shown by the jet-plane series on the facing page, normal photographic techniques cannot compensate for the extreme range of intensities between the inner and outer parts of the corona. When exposures are lengthened to record the outer corona, parts close to the sun are badly overexposed. To equalize these intensities, M. Laffineur, Miss M. Bloch, and Miss M. Bretz placed a rotating sector near the focal plane of their 3.6-meter camera, which was set up at Haute Provence Observatory in southern France. The sector reduced the intensity 64 times as much at the sun's edge as at points 1½ solar radii distant. A filter and the long-wave insensitivity of the Agfa Isopan-Ultra film limited the spectral region to the red between 6100 and 6450 angstroms. This is a 10-second exposure, developed for 15 minutes in Atomal. The French astronomers attribute the slight defects in the photograph to imperfections in their red filter and to a somewhat delayed closing of the shutter at third contact. Photograph courtesy M. Laffineur, Institut d'Astrophysique, Paris.

the sun's edge breaks into Baily's beads, the darkness rushes in as suddenly as if a giant curtain had been pulled. This same sequence of color and light changes will occur after totality, as the moon moves away from the sun. But it is by no means as impressive as in the last moments before totality. The corona makes its dramatic appearance. Totality has begun.

After taking my scheduled pictures, I can examine the corona through the pointer telescope. It is, even to the naked eye, the most beautiful corona that I've ever seen — and this is my ninth eclipse, of which six (including this) were clear and one partly clear. I have the impression that today's eclipse is not quite as dark as most of those others.

The sun's outermost atmosphere has a

A 0.3-second exposure at second contact, with the Rome 5½-inch telescope, shows Baily's beads, prominences, and a long arc of the solar chromosphere.

distinctive shape, suggesting a cat with two pointed ears sticking out to the right and left near the top and with some whiskers in the lower half. The corona's form is of the so-called intermediate type, having neither the irregular wind-blown aspect typical of sunspot maximum nor the long equatorial extensions characterizing sunspot minimum. It reminds me vaguely of photographs of the 1922 eclipse in Australia. In the "cat's ears" I can see clearly the petaled structure that has often been reported in these raised coronal mounds.

Delicate pink prominences are set against the sharply white corona. I say "pink," but there is also a lavender associated with them, something I remember from the 1936 eclipse in Siberia. This shade is undoubtedly caused by the

In a carnival preceding the eclipse, the astronomer (complete with telescope) is flanked by a sad-faced moon (left) and a bright, cheerful sun.

strong ionized calcium lines in the far violet, which temper the red from the hydrogen line. The prominence hues are definitely pastel.

Suddenly a pinkish crest appears on the moon's western edge, below the white, delicately frosted lines of the corona. This is the solar chromosphere, which shows for but one or two seconds before the brilliant sun itself flashes out. Now I watch carefully and find that I can detect the corona for fully 15 or 20 seconds after totality has ended.

Before the partial eclipse is over, Mr. Moreton and I are already examining our pictures of the corona, thanks to the Polaroid process. They are adequate, considering the simple character of our equipment. The third camera, unfortunately, did not fare as well. The dampness caused the focal-plane shutter mechanism to stick, and we find our pictures have little scientific value because of camera vibration and double exposures.

Nevertheless, they are sufficiently clear to show that the flat characteristic curve of the Polaroid film has excellent potentiality. Faint extensions of the corona are recorded without burning out the brighter interior. I should like to try this film again, with a longer-focus camera.

The camp is now a scene of bustling activity. Astronomers vie with one another for use of the tiny darkroom. Reporters and cameramen, excluded during totality, now enter and ask for interviews, while the television and radio crews move in for close-ups of the expedition activity. The TV cameras had broadcast our pre-eclipse preparations, as well as direct views of the eclipse in the sky. Over the telephone, I give my impressions of the eclipse to a representative of the National Broadcasting Company, which will presently transmit an account of the eclipse to America. Some of the first plates are already developed, dried, and used to make preliminary prints for circulation among us.

In general, our fellow expeditions have been successful. Assisted by Miss Kerstin Fredga, Professor Ohman obtained a good infrared spectrum, and he is happy with the results. The Italians carried out their programs, and the French obtained excellent standardized photographs of the corona. What their pictures tell must await refined measurements of the plates after they return to Meudon.

As the day wears on, results and weather reports filter in from other places. The threatened storm had moved northward over England, but the eclipse there was only partial. The clouds extended into Bordeaux. We heard about a French astronomer who arrived there by train just one hour before totality. Seeing how threatening the weather was, he stepped back on the train and, fortunately, was carried from under the clouds to a place where he saw the total phase very well.

Even some days later, detailed results had not come in from the Soviet astronomers. At Rome, however, Mrs. Alla Massevich told me that one group of astronomers, flying in a Soviet jet, had managed to lengthen totality to a full four minutes.

The writer has gathered pictures, reports, and information concerning a large number of expeditions to this eclipse. In next month's concluding half of this account, I shall review these results. Meanwhile, I acknowledge especially the support of the Air Force Cambridge Research Laboratories, the hospitality of Professor Cimino and the director and members of the meteorological observatory.

And we cannot forget how the local civic groups went out of their way to entertain us. The official reception was very gay, but the crowning social event came at sunset on February 13th, the day of a carnival celebrated just before Lent. The major portrayal in our honor was an astronomer with pointed hat and telescope. He rode upon a turtle, for some reason I could not quite understand. Accompanying him were two costumed figures representing the sun and the moon. For photographers, they gladly enacted *l'eclisse* in pantomime.

We were next escorted to a small shop, facing the waterfront, to view an art exhibit and judge some paintings in which colored foodstuffs furnished the pigments. Mayonnaise and cheese provided yellows and oranges, jellies the reds, and so on. With some difficulties, we came to a decision, and I then received as a special gift from a seven-year-old girl her painting of an astronomer observing a total eclipse. This picture is dated February 12, 1961.

The city of Pisa, Italy, which lay very close to the central line of totality, was visited by the author one night during his travels. With high-speed Polaroid film, he was able to take this picture of the famous tower. Its construction began in 1174, and it started to lean even before it was finished. By the 20th century it was tipped about five degrees from the vertical.

Contact Binaries

OTTO STRUVE, *National Radio Astronomy Observatory**

IN the year 1903 a remarkable variable star was discovered by G. Müller and P. Kempf at Potsdam Observatory, during photometric measurements for the compilation of a catalogue of all northern stars brighter than magnitude 7.5.

This star, W Ursae Majoris, was soon recognized to be an eclipsing binary with the extremely short period of eight hours. Its light curve shows during each cycle two minima of nearly equal depth, resulting from mutual eclipses of two similar stars. A noteworthy property of the curve is the continuous change in brightness between minima, very unlike Algol, which has a nearly constant maximum light.

This feature indicates that the components of W Ursae Majoris are not spherical, but elongated toward each other. They are, in fact, nearly in contact, and each star is strongly distorted by the gravitational attraction of the other. The combined light reaches a maximum when the two components are presented broadside to the observer, and as the orbital motion proceeds, their diminishing apparent cross sections cause a fading before eclipse begins (see Fig. 2).

Today many hundreds of similar variable stars are known, and even though two or three had been discovered before W Ursae Majoris, the latter has given its name to the class.

From the viewpoint of the astrophysicist, perhaps the most significant property of these binaries is the small distance between the components, allowing significant physical interaction. Hence it is useful to include them in the class of *contact binaries*, a name first introduced, I believe, by G. P. Kuiper and independently by Z. Kopal. Contact binaries range from such massive systems as Beta Lyrae, whose period is about 13 days, to late-type W Ursae Majoris systems with periods of a quarter day.

In a recent article, as yet unpublished, Olin J. Eggen of the Royal Greenwich Observatory has listed the principal properties of contact binaries, and has summarized his own observations of the magnitudes and colors of 46 of these systems with periods less than 1.5 days.

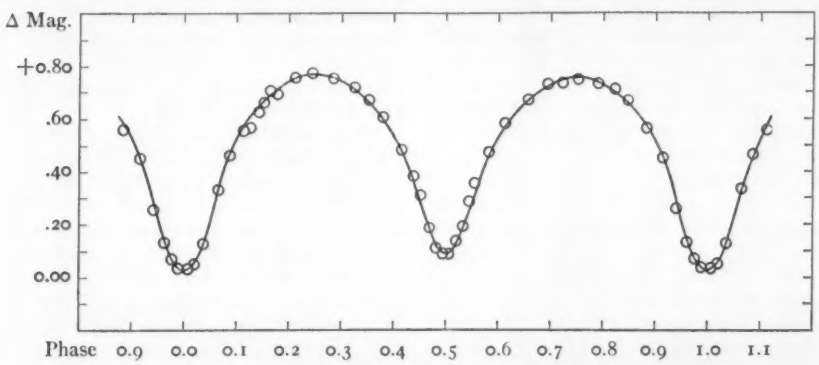


Fig. 2. This light curve of W Ursae Majoris was derived by C. M. Huffer in 1934. Each point on it is the average of six photoelectric observations made at Washburn Observatory. The shape is typical of contact binary curves. Courtesy "Astrophysical Journal."

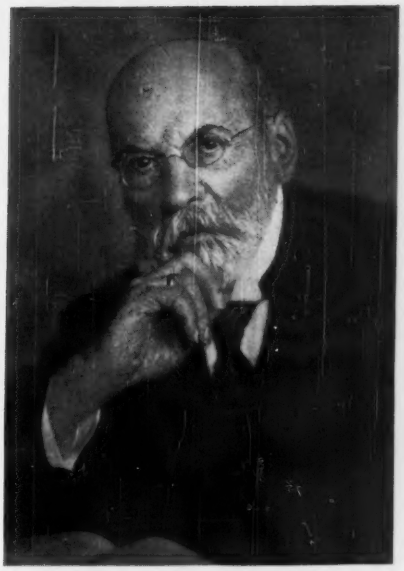


Fig. 1. The German astronomer Gustav Müller (1851-1925) was an outstanding expert on variable stars. A specialist in visual photometry of high precision, he served as director of the Potsdam Astrophysical Observatory from 1917 to 1921.

Some years ago, Eggen, M. Huruhata, and others discovered the light curves of contact binaries occasionally undergo erratic changes (Fig. 3). Relative depths of the two minima and the brightnesses of the maxima can change from season to season, and sometimes from cycle to cycle. This adds to the great difficulty in deriving meaningful orbital elements for these systems. Hence our detailed understanding of contact binaries does not come primarily from analyses of light curves, but from studies of combined magnitudes, colors, and spectra.

The spectroscopic peculiarities of con-

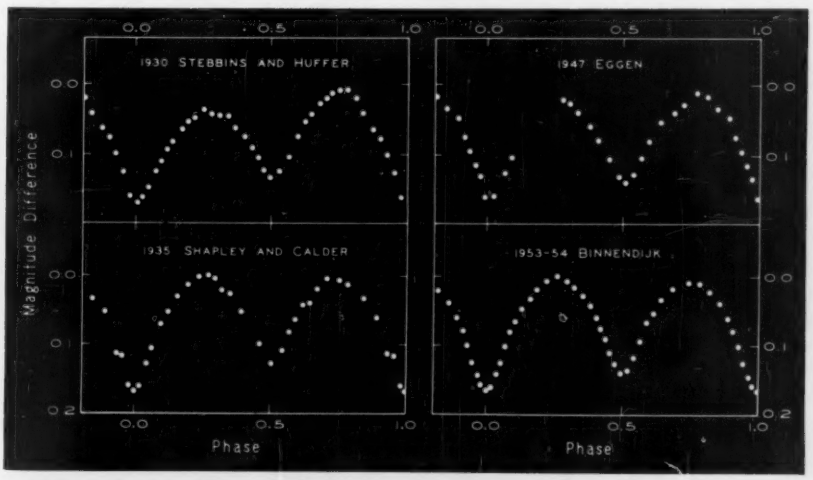


Fig. 3. Changes in the shape of the light curve of 44i Bootis, a W Ursae Majoris-type binary, are indicated by photoelectric observations in different years. For example, the hump in the maximum that follows primary minimum became smaller and finally disappeared. The zero points have been adjusted to agree. Flower and Cook Observatory diagram by L. Binnendijk.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

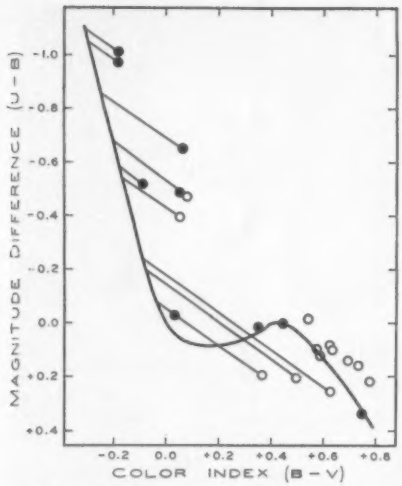


Fig. 4. Olin J. Eggen's observations of the colors of 22 contact binary systems. Open circles indicate stars fainter than visual magnitude 10 at maximum light. The vertical scale is the difference between ultraviolet (U) and blue (B) magnitudes; the horizontal scale between blue and yellow (V) magnitudes. These photoelectric measurements were made with the Cape Observatory 18-inch and the Radcliffe Observatory 74-inch reflectors in South Africa.

tact binaries with periods shorter than about half a day include:

a. Although the spectra usually show absorption lines belonging to both components, the intensities of these lines are often variable in such a way that the violet-shifted ones tend to be stronger than the red-displaced ones, irrespective of which star is approaching.

b. The spectral type appears to be later when the stars are in eclipse and the absorption lines are single, regardless of which component happens to be eclipsed.

c. The presence of double absorption lines implies that the luminosities of the stars are approximately the same. If both obey the mass-luminosity relation, we should expect them also to have similar masses. However, the velocity curves of the pair usually indicate that one component has two or three times the other's mass.

J. Sahade, Eggen, and others have pointed out that several W Ursae Majoris systems are members of well-known galactic star clusters whose ages are tens or hundreds of millions of years. Hence these stars are relatively young, although their spectral types are often as late as *G* or even *K*.

Eggen's photoelectric observations, made with instruments ranging from the 12-inch Lick refractor to the 74-inch reflector at Pretoria, have been accumulated during several years. His results can best be described by means of his own diagrams.

Fig. 4 shows observed values of the ultraviolet-minus-blue color indexes plotted against the blue-minus-visual color indexes. The continuous curve represents unreddened main-sequence stars; its dip at the lower left is due to the very strong hydrogen absorption lines in spectral classes near *A*0. The inclined straight lines represent the reddening caused by interstellar dust. For some of the stars, which presumably are not reddened by intervening cosmic clouds, the observational points lie fairly close to the unreddened curve.

Fig. 5 depicts the observed relation between the stars' periods and their B − V color indexes. The general pattern of points is in accord with the well-known fact that contact binaries of very short period, about 0.25 day, are the reddest, with color indexes near +0.85. Systems whose periods approximate one day are much bluer, having color indexes of about −0.2.

Eggen believes that the distribution of points in Fig. 5 is not uniform and that it may in fact be possible to distinguish the three separate groups he has marked by shaded areas in Fig. 6. There will probably be a good deal of discussion as to the reality of these subgroups, but for the present we must accept Eggen's judgment, as it is based on his thorough familiarity with the accuracy of his observations and with the reddening corrections he has applied.

The question now arises whether it is possible to explain the color-period diagram in terms of theoretical data. From Kepler's third law, it is easy to calculate that the orbital period of two *undistorted* suns in contact would be 0.235 day. A formula giving the corresponding periods for other stellar radii and masses is readily obtained. Then, from known relations between mass, luminosity, temperature,

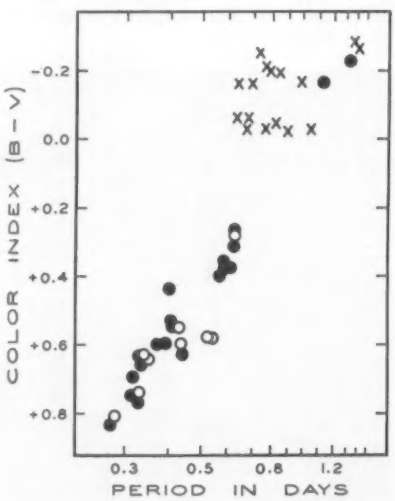


Fig. 5. Forty-five of the systems observed by Dr. Eggen are plotted here, with circles indicating stars fainter than visual magnitude 10 at maximum light. The crosses represent pairs whose colors are corrected for interstellar reddening.

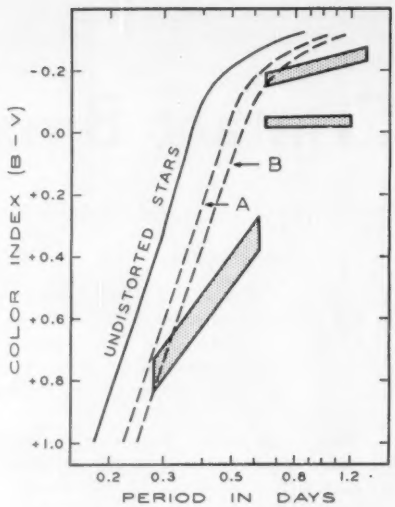


Fig. 6. Shaded areas in this color-period diagram mark the positions of three subgroups to be compared with the theoretical curves.

and color, the formula can be converted to express period in terms of color. Eggen has done this for main-sequence stars, his final result being the color-period relation corresponding to the curve labeled "undistorted stars" in Fig. 6.

It is immediately apparent that this theoretical curve in no way represents the observations in Fig. 5. However, the assumption that two stars can be in contact without being seriously distorted in shape is not realistic, so Eggen next computed two additional curves, represented by dashed lines, for distorted stars. Curve **A** is for stars of equal mass and is based on the Roche model, which implies a strong central concentration of mass; curve **B** is for stars of nearly homogeneous structure. If the masses of the components in any system are not the same, the effect of distortion would be smaller than indicated by either dashed curve, and the theoretical plot would fall closer to the curve for undistorted stars than do curves **A** or **B**.

From an inspection of Fig. 6, Eggen concluded that only the reddest systems (lower left) agree reasonably well with the dashed curves, and perhaps also the bluest stars (upper right). However, the slope of the shaded area between periods of 0.27 and 0.60 day disagrees strongly with the computed curves, and there is no agreement whatever in the case of the nearly horizontal shaded area located at color index 0.0.

In order to explain these discrepancies, Eggen next attempted to compute color-period relations for stars that have had time to evolve away from the main sequence. The results of these computations are shown in Fig. 7. The theoretical models for evolving stars were taken from the work of L. G. Henyey, R. LeLevier, and R. D. Levee, as well as from studies by F. Hoyle and his associates.

For example, a main-sequence star of

two solar masses is represented by a dot from which a downward-slanting dashed line indicates the track in the diagram that such a star would follow as it aged to 10^8 years. A similar but longer track is shown for a star of 3.5 solar masses. By connecting the end points of a number of such lines, a theoretical color-period relation is obtained for systems of different masses but all 10^8 years old.

Thus, the intermediate group of contact binaries may be reasonably well interpreted as consisting of systems with ages of approximately 10^8 years, whereas the uppermost group appears to have ages near 10^7 years. Unfortunately, the many systems at the bottom of the diagram are not satisfactorily explained in terms of a single group about 10^9 years old.

Eggen points out that the cluster ages of some of these stars are actually about 10^8 years and that it would, therefore, not be reasonable to expect agreement with the 10^9-year line. He does not give a theoretical interpretation of this important group, but speculates that they may be relatively young, contracting objects that have evolved out of the T Tauri class of variables.

I believe that many astronomers will find it difficult to agree that there are actually three distinct groups of contact binaries, despite Eggen's attempts to show that there are few if any systems with B — V colors near —0.1. The break between the lower two groups is probably real, but note that all the stars redder than +0.2 are uncorrected for interstellar reddening, while all but two of those bluer than 0.0 have been corrected by fairly large amounts.

Nevertheless, Eggen's work does indicate that a simple theoretical color-period relation for distorted stars of equal mass revolving in contact is unable to reproduce the observations. He has considered but discarded a number of other factors, such as a mass dependence in distortion of the components. Also it is possible that the bluer systems are not true contact binaries and that the internal density distribution of the components may vary over the range of stars concerned. Any of these, when allowed for in the calculations, could change the slope of the theoretical curve.

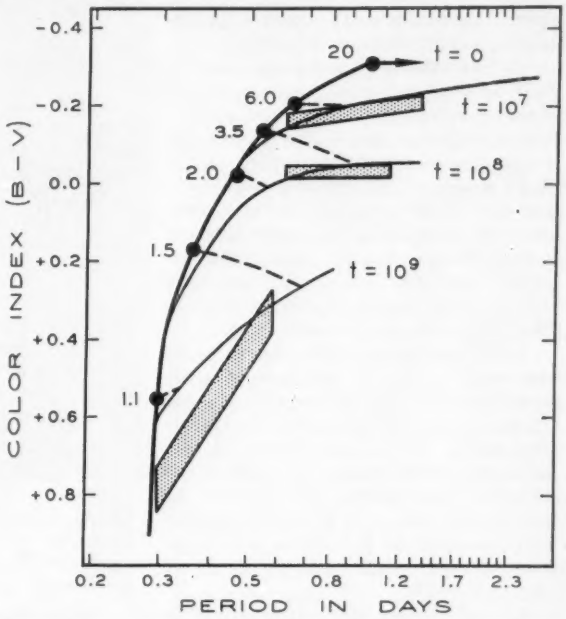


Fig. 7. Here two shaded areas lie close to the theoretical distribution curves for stars that have ages 10 and 100 million years, respectively, from the zero-age main sequence. The numbers from 1.1 to 20 represent solar masses. In this article, Figs. 4 through 7 are reproduced courtesy Olin J. Eggen, Royal Greenwich Observatory.

LETTERS

Sir:

On page 15 of the January, 1961, issue of SKY AND TELESCOPE, Edgar Everhart remarked that the arc labeled **K**, opposite the sun in the halo complex of September 17, 1960, might not actually be a part of the phenomenon, since he had never before seen reference to it. Such a feature, however, was observed in the fine halo display of March 10, 1920, seen in southern Finland and noted in R. Meyer's work, *Die Haloerscheinungen*, page 4.

An unusual halo, occurring between 12:25 and 12:50 Eastern standard time on February 6th this year, was reported to me by 13-year-old Arthur Baron, 69-04 228th St., Bayside 64, N. Y. He saw not only a complete horizontal circle, like that in last September's display, but a pair of parhelia or countersuns on the circle 120 degrees to either side of the sun.

HERBERT A. LUFT
69-11 229th St.
Oakland Gardens 64, N. Y.

Sir:

My observations of Jupiter in 1960 supplement Terence Pearce's account (February issue, page 97) of the conjunction of the well-known red spot with a large white oval in the south temperate belt. This is one of three long-lived ovals followed since the 1940's by British and American amateurs; it has been designated BC by Elmer Reese.

For my work, I used a 10-inch reflector in Buffalo, New York, and a 17-inch in Edinburg, Texas. Measurements of the positions of BC on about 20 of my drawings gave 9 hours, 55 minutes, 11½ seconds, for its period of revolution, while that of the red spot was 31½ seconds longer. From a plot of their drifts, it seems that BC overtook the red spot about August 29th.

The red spot was unrecognizable in 1959 and early 1960. It began to develop from its practically invisible hollow during April, 1960, and was a well-formed ellipse in May. Mr. Pearce, observing in London where Jupiter was always low in the sky, described the spot as gray. With larger telescopes and the planet higher above the horizon, I found it to be a brilliant orange. And instead of fading during August and September, as Mr. Pearce reported, the red spot remained prominent until I last saw it, during the first week of December.

CLARK CHAPMAN
2343 Kensington Ave.
Buffalo 26, N. Y.

ED. NOTE: In Mr. Pearce's article, an editing error was made in the first paragraph. The oval should have been described as in the south temperate belt, not south tropical belt. This was pointed out by David B. Williams, Normal, Illinois.

Sir:

Some interesting facts can be deduced from the latest Soviet map of the moon's opposite side [reproduced on page 135 of last month's SKY AND TELESCOPE].

An important difference between the two hemispheres is the comparative lack of large mare basins on the farther one. So far, 10,530,000 square kilometers of the far side have been observed, while 8,439,000 remain unstudied. On the new map, I have measured the combined areas of the far-side basins as about 1,450,000 square kilometers, of which the Sea of Dreams contributes about 640,000 and the Moscow Sea 30,000.

Hence, on the known part of the farther hemisphere, the area of maria to the area of the "continents" is 1 to 6.26. For the nearer hemisphere, this ratio is 1 to 2.99.

The late H. P. Wilkins had published a conjectural map of the moon's other side in the *Journal* of the British Interplanetary Society, *12*, 1, 1953. This contains a large ray system whose center may be identical with Astronauts' Bay. Another ray center, not far from the Soviet Range, could be one of the craters Edison, Lomonosov, or Maxwell. Two other Wilkins centers are perhaps to be identified with Lobachevsky and Pasteur.

PETER HEDERVARI
VII. Damjanich-st. 28/b
Budapest, Hungary

OBSERVING THE SATELLITES

Sputniks VII and VIII

A NEW RECORD for weight placed in orbit around the earth was claimed by the Soviet press when Sputnik VII was launched from the U. S. S. R. early on February 4, 1961. An "improved multi-stage rocket" was apparently being test-fired, the resulting 6,483-kilogram (14,293-pound) satellite proving its success.

The intended orbit is reported to have been attained with great precision. Radio tracking equipment aboard the satellite and a telemetry system "to control the parameters of the different parts of the ship's structure" are the only announced features of the payload. About a week after the launching, the Soviet scientist Leonid Sedov officially denied that research apparatus or living animals were aboard. This suggests a close relation to the Venus shot of a few days later.

Russian announcements merely term the heavy satellite a "new kind of spaceship." In the United States it is being called Sputnik VII or 1961β1. Its launching rocket, which accompanied it into orbit, is 1961β2, while an unidentified third part is in orbit as 1961β3. Only the last survived through February; Sputnik VII re-entered the atmosphere late on the 26th, while the rocket case burned up on the 12th or 13th.

For all of these objects the orbital inclination was close to 64°.9. The initial anomalistic periods were 89.8, 89.95, and 90.3 minutes for the three components taken in numerical order. Perigee heights were 124, 133, and 146 miles, apogees 210, 211, and 221. These orbital values are largely based on passive tracking of the satellites; many supposed telemetry signals detected by Western observers were claimed by Russian announcements to be spurious.

Study of the orbital elements of 1961β3 suggests that it attained its final thrust after Sputnik VII separated from its rocket, perhaps during the second revolution around the earth. Was this a rehearsal of the separation maneuver later used for the Venus probe launching?

Sputnik VIII is memorable as providing for the first time an orbiting base from which an interplanetary probe was launched. Late on February 11th or early on the 12th, another "heavy artificial earth satellite" (of unannounced weight) was placed in orbit; later "on the same day a guided space rocket, launched from the Sputnik, set an automatic interplanetary station (1961γ1) on a flight toward the planet Venus."

The advantages of a "parking" orbit around the earth as a launching base for interplanetary flight have been discussed for years. In the present case, it is possible to reconstruct the probable nature of the operation.

Consider first the orbit of Sputnik VIII, which is inclined 65°.01 to the earth's equator, according to information distributed by the National Aeronautics and Space Administration. The ascending node (the point where the satellite passes northward through the equator's plane) was initially at right ascension about 186°.

During an early revolution (possibly its first), Sputnik VIII was approaching its ascending node shortly before 2:06 Universal time on February 12th. It was traveling northward at a height of about 125 miles over the region of the Congo River. Suddenly a rocket bearing the 1,419-pound space station separated from the Sputnik and began to fire, somewhat to the right of the direction of travel.

The resulting maneuver was like that of a swerving speedboat skidding into a powered dog-leg turn. When it was complete, the probe was about 185 miles above the Gulf of Aden, near the perigee point of a new hyperbolic path. This perigee was passed at 2:06 UT. The orbit plane of the probe had very nearly the same ascending node as the satellite's, but the inclination was only about 24°.3 instead of 65°.01.

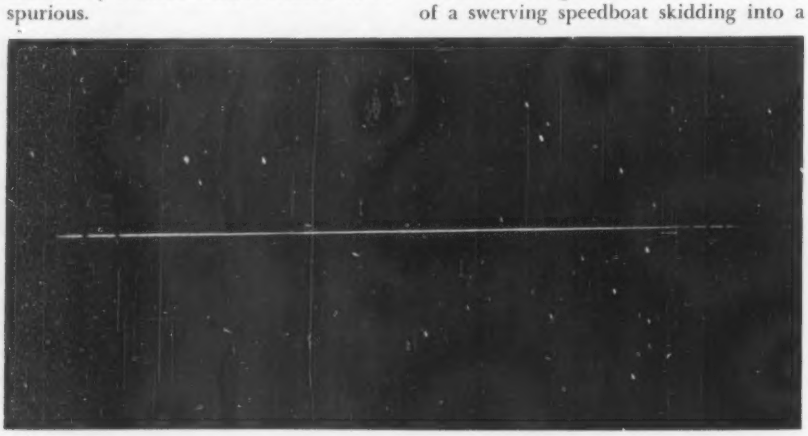
This new orbital inclination, made possible by the launch-in-orbit technique, could not have been attained in a straight-away shot from anywhere inside the Soviet Union. Neither could the resulting perigee latitude of +14°.7, with 1961γ1 passing northward, have been possible in a direct shot from a Soviet base.

After the launch-from-orbit feat, 1961γ1 was traveling in a new plane, with greatly increased velocity. When its motion was still dominated by terrestrial gravitation, the probe was approaching asymptotically a point in the sky at right ascension 8°, declination −1°, near the star 14 Ceti. Clearly, the geocentric motion was nearly in the plane of the ecliptic.

Later, the Venus probe receded far enough from the earth for its path to be dictated by solar attraction. From the various positions, not always consistent, that the Soviet news agency announced, NASA has distributed values for the elements of its path around the sun. The object is moving in a 300-day orbit, inclined only 0.3 degree to the ecliptic, with perihelion and aphelion distances of 0.7183 and 1.019 astronomical units, respectively. Probably the separated launching rocket is following a similar track. Thus perihelion lies inside the orbit of Venus, aphelion outside the earth's. Such a route, intersecting both planetary orbits, requires a greater velocity than for travel along a semiellipse tangent to both of them. The launching was about one month too late for motion along a so-called Hohmann ellipse (Sky and Telescope, May, 1959, page 378). It has been announced that the probe will pass within 65,000 miles of Venus on May 19th or 20th.

The "automatic interplanetary station" is a cylinder capped with an instrumented dome and bearing four antennas, fins of solar-cell panels, and heat-regulating shutters. Apart from projecting antennas and fins, it is 6.7 feet long and 3.4 feet in diameter. There is a complex orienting system that points the antennas to earth, and presumably turns the solar-cell fins toward the sun. When the neighborhood of Venus is reached, the system will stabilize and orient the probe for an ambitious but undisclosed observation program.

Some of the announced purposes are familiar from the program for Pioneer V, the American probe launched toward Venus on March 11th last year (see page 409 of May, 1960, issue; and page 337 of December). Like its predecessor, 1961γ1 is being used for a redetermination of the astronomical unit of distance. But



Two days after its launching, Explorer IX (Baby Echo) was photographed by the Baker-Nunn camera at the Smithsonian satellite tracking station, Jupiter, Florida. The time was 10:27 UT, February 18th, when the 4th-magnitude balloon was 540 miles high and 680 miles distant from the camera. Traveling toward Polaris about one-third degree per second, it was passing near Merak in the Big Dipper. The trail is about 2½ degrees long, the breaks at either end being due to a rotating shutter used for timing the satellite's positions. Smithsonian Astrophysical Observatory photograph.

the plan of work is presumably different, for Doppler measurements of Pioneer V were made at frequent intervals. The new probe was to be interrogated only every fifth day, probably to conserve power.

Tests of radio communications over interplanetary distances are another objective of the Soviet experiment, and large receiving antennas have been erected at various sites. So far, no radio signals have been received by large Western radio telescopes, according to NASA. About the beginning of March, Russian scientists said that the signals had been lost, but efforts were to be made later to restore contact.

Meanwhile, three short-lived components left behind in circumterrestrial orbits have been tracked. According to NASA, the original launching rocket, 1961γ2, re-entered the atmosphere on February 18th, followed a week later by Sputnik VIII itself, 1961γ3. Earlier, an unidentified fragment, 1961γ4, burned up during descent. All of these had inclinations of 65°. Initial nodal periods were 89.6, 89.8, and 89.5 minutes, respectively; perigee heights, 128, 124, and 124 miles; apogees, 190, 206, and 190.

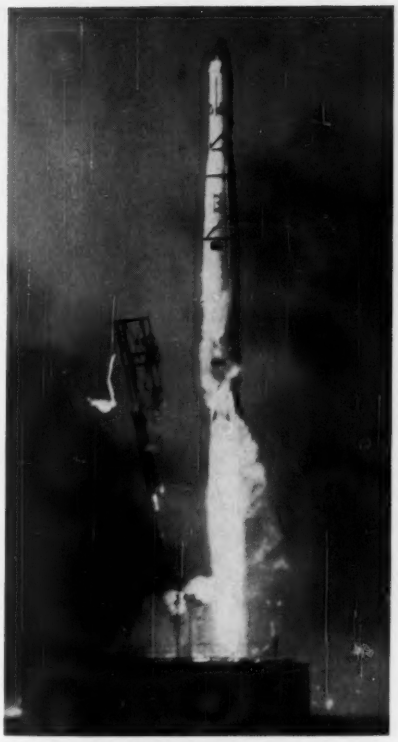
Explorer IX

ON February 16th, at about 13:05 UT, a Scout four-stage rocket blasted away from its launching boom at Wallops Station, Virginia. Some 15 minutes later, its polka-dotted Baby Echo balloon went into orbit, the first successful satellite launching by the Scout all-solid-fuel system, and the first from Wallops Island. Both the Scout and the air-drag experiment for which its balloon is intended were described on page 142 of last month's issue.

Since the final-stage rocket was equipped with a transmitter for telemetry and tracking, the fact that it had attained orbit was readily established during the first revolution. This final stage, named Altair, has a fiberglass casing about 18 inches in diameter and six feet long. It weighed about 62 pounds and carried another 65 pounds of inflation equipment, radio apparatus, and batteries.

Signals telemetered from the rocket told that the balloon had been ejected, inflated, and then separated from the Altair. However, the balloon's own tiny radio failed. Before NASA would confirm that the 15-pound 12-foot sphere was in orbit, it had already completed more than a dozen revolutions. Not until balloon and rocket were well apart did optical and radar observations convince officials that *two* objects were in orbit. Millstone Hill radar signals returning from the balloon verified that the structure was fully inflated, and then NASA announced its status.

The balloon is called Explorer IX (1961δ1). Its orbital inclination is about 38.9 degrees. Initially, its anomalistic period was about 118.4 minutes, with perigee and apogee heights of 395 and 1,602 miles, respectively.



The launching of Discoverer XX, shown in this U. S. Air Force photo of the Thor booster topped by an Agena B, placed the series' heaviest payload in orbit.

The heavier rocket casing, 1961δ2, will not be affected as much by atmospheric resistance as will the balloon. Its orbit is closely similar, with a period of 118.55 minutes initially, and apogee a few miles higher than the balloon's.

Compared with the 100-foot balloon of our first Echo satellite, 1960ι, the Explorer IX sphere is much less subject to the effect of the pressure of sunlight. NASA is planning future giant balloons, even larger than Echo, to serve as passive radio reflectors. While Echo has shown an unexpected stability in shape and has a low rate of gas loss, its successors will be made of stiffer plastic.

Discoverers XX and XXI

TWO more Discoverer satellites were launched from Vandenberg Air Force Base, California, on successive days in February. The first, Discoverer XX, took off on the 17th at 20:25:02 Universal time. The weight in orbit of its Agena-B stage, 2,450 pounds, was the heaviest so far in the series.

Part of the additional weight in this case was extra batteries and a larger supply of compressed gas for maintaining the orientation of the Agena over a longer time than in earlier launchings. The reentry capsule was to have traveled four days in orbit before its recovery was begun, but on February 21st the Air Force Ballistic Missile Division announced that recovery would not be attempted because equipment in the satellite had failed.

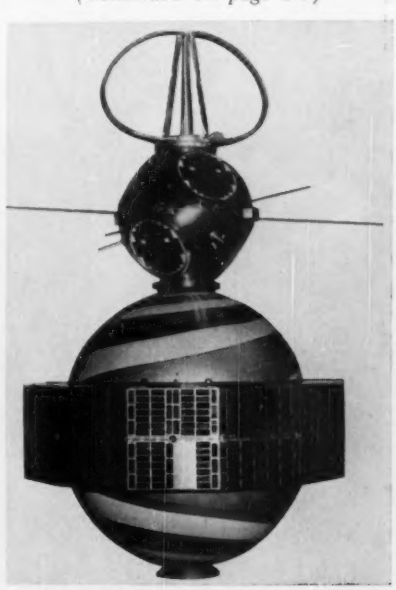
Among the specimens orbiting in the satellite but now lost were some silicon samples. It had been hoped to observe the effect of high-energy protons upon the almost pure element, which is used in semiconductor devices, such as transistors and solar cells.

The orbit of Discoverer XX, 1960ε, is inclined 80.91 degrees to the earth's equator. Initially, the nodal period amounted to 95.4 minutes, with perigee and apogee heights of 185 and 498 miles, respectively. On this occasion the apogee position was almost 55 degrees south of the equator, a larger distance than in earlier shots.

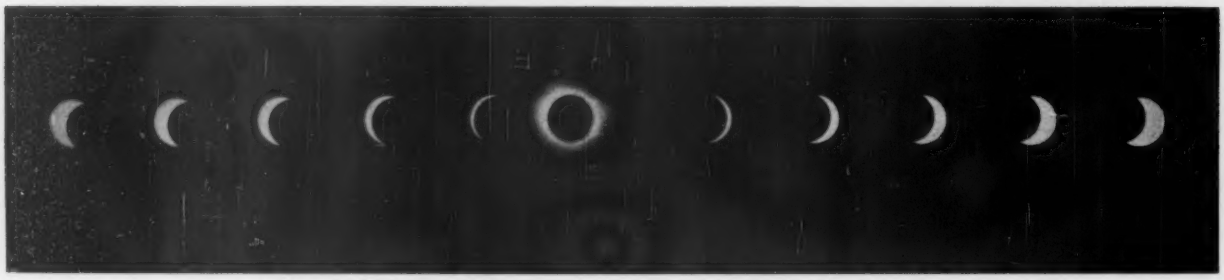
On February 18th, Discoverer XXI was launched at about 22:58 UT. The later time of day than for Discoverer XX was chosen to separate their orbit planes, thus simplifying tracking. The most notable new achievement on this flight was the restarting of the Agena-B engine more than an hour after it had been turned off.

During the first revolution, the orbital period was about 93.8 minutes, measured from node to node. Near the end of this circuit, when the orbiting Agena again neared the Pacific Missile Range, command was given to start the engine for a second time. The new impulse was brief — perhaps lasting only about a second — but sufficient to increase the nodal period by some four minutes, to about 97.86 minutes. The perigee and apogee heights immediately following restart of the engine were 157 and 813 miles, respectively. The inclination was 80.74 degrees, and again apogee was reached

(Continued on page 209)



Failure to separate from the final-stage rocket marred the launching of the Transit III-B navigation satellite, which also remained attached to Lofti (see page 209). Photograph courtesy Johns Hopkins University.



The sun in eclipse on February 15, 1961. These 11 exposures are part of a series of 13 made at five-minute intervals by A. H. Catá near Valence, France, 150 miles northwest of Nice. The left-hand exposure was made at 7:10 Universal time.

Reports from February Eclipse Observers

THESE are some of the many accounts of the eclipse of the sun on February 15th that have been received by SKY AND TELESCOPE.

VALENCE, FRANCE

For me, reaching the eclipse path near the city of Valence, France, in the Rhone Valley, required a motor trip of only 160 miles. My observing site was on top of a hill in the little town of St. Romain, about eight miles from the city.

My Japanese camera is a Rittreck, with an f/4.5 lens of 21-cm. focal length. The $2\frac{1}{4} \times 2\frac{1}{4}$ Kodacolor negative was later enlarged four times for the black-and-white print of the series seen here. The camera remained fixed, while an exposure was made every five minutes for an hour, beginning at 7:05. The picture of totality seems displaced because it occurred at 7:33:42 Universal time.

For the partial phases, I stopped down to f/16, used an overexposed film in front of the lens as a filter, and exposed 1/200 second. The total phase was taken without the filter, 1/20 second at f/4.5.

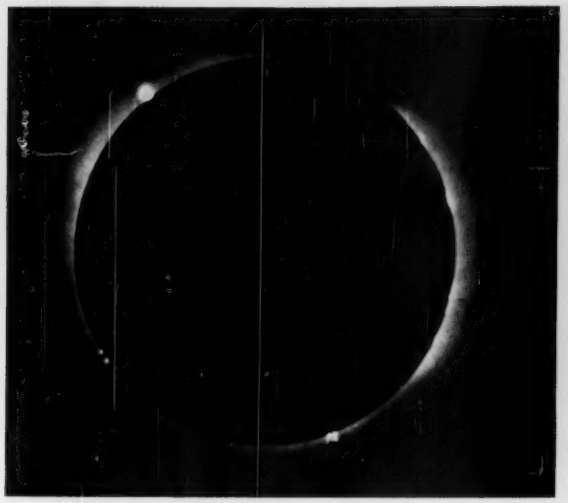
A. H. CATÁ
U.I.T., Palais Wilson
Geneva, Switzerland

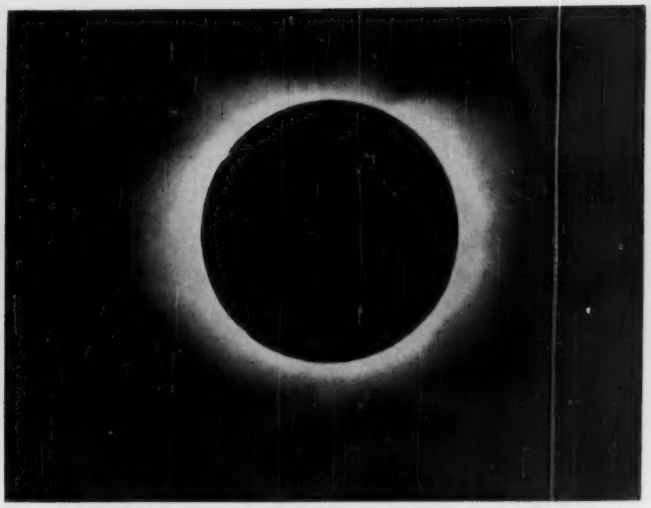
SAN REMO, ITALY

Weather conditions were very satisfactory at Mt. Bignone, 4,200 feet above sea level north of San Remo, Italy. During the 118 seconds of totality, we secured 46 color slides with exposures varying from two to 1/100 second.

On Super Anscochrome film we recorded the outer corona with an f/6 4-inch Aero-Tessar lens and one-fifth second exposure. The picture of the inner corona and prominences seen here was made with a 4-inch reflector and Barlow lens, the effective focal length being 64 inches. The exposure was 1/40 second, being made on

Citizens from the village of Velo Grablje on the island of Hvar look in upon the observing site of the eclipse expedition from Zagreb University, Yugoslavia. Dr. Andro Gilic, who obtained the middle-corona photograph at the top of the opposite page, stands beside his Zeiss telescope. He was assisted by his daughter (seated).





The inner and middle solar corona, photographed from San Remo, Italy, and Hvar, Yugoslavia, respectively. North is toward the top. Gerhart Klaus gives the position angles of the six prominences visible in his picture, starting with the conspicuous flare at upper left and moving counterclockwise, as 39°, 121°, 123°, 200°, 285°, and 304°. The solar north pole is at roughly 340°. Andro Gilic made the one-second exposure on the right at 7:40:54 Universal time, on Isopan film with a Leica camera and a telescope of 42-cm. focal length.

Eastman High Speed Ektachrome film.

W. Bohnenblust accompanied me on this expedition. We are members of the Swiss Astronomical Society.

GERHART KLAUS
10 Waldeggstrasse
Grenchen, Switzerland

The Islands off Yugoslavia

Observers along the Yugoslavian coast achieved outstanding success. Many teams of amateur and professional astronomers were located near the port city of Split and on the islands of Hvar and Brac. Interior areas of the Balkan peninsula were overcast, as had been expected from meteorological records. Inhabitants of such towns as Ljubljana, Zagreb, Sarajevo, and Mostar could only glimpse the eclipse through fog or clouds. A Eurovision TV camera was stationed on a 4,900-foot mountain near Nis, in eastern Yugoslavia, but failed to broadcast the event. The well-known British amateur Patrick Moore was part of the Eurovision team.

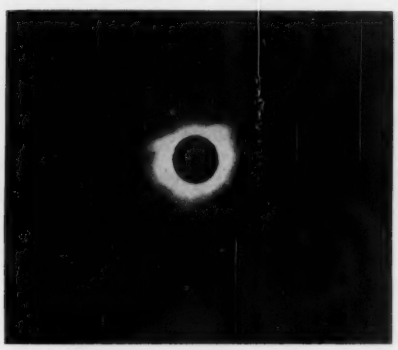
In contrast, on February 15th the central part of Yugoslavia's Adriatic coast lay under a high-pressure system. It was like summer, with no wind and the sky completely cloudless. Local residents said it was the first time such clear weather had occurred this year.

On the island of Brac, the 2,500-foot summit of Mt. Vidova was the observing site for some 80 amateur astronomers, from Austria, West Germany, Luxembourg, Switzerland, and Croatia. Dutch astronomers on this island observed at Sumartin, and at Bol there were amateurs from East and West Germany.

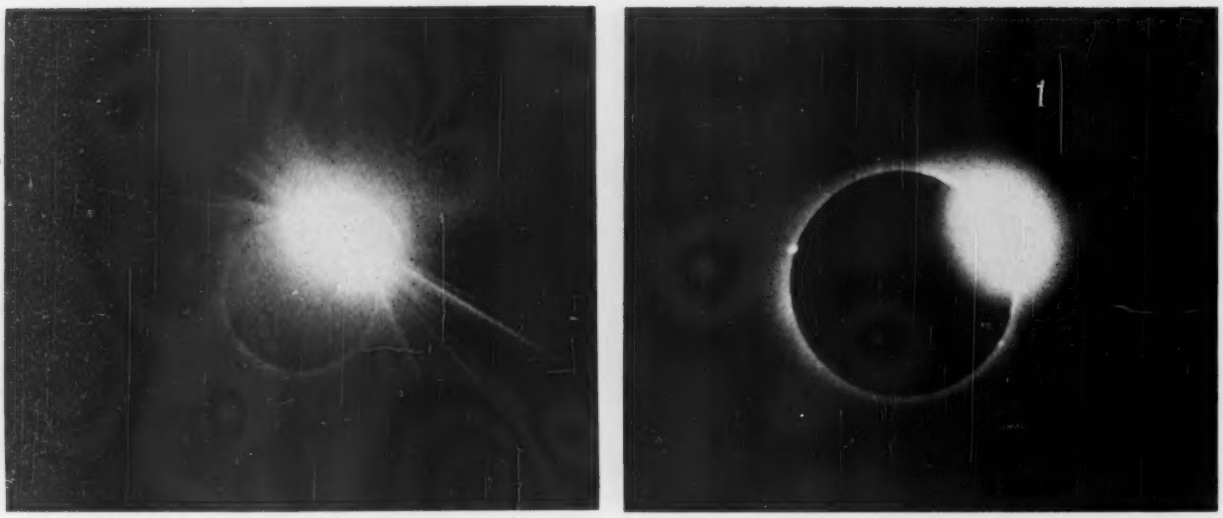
Near the town of Hvar on the island of the same name, a Greek team photographed the eclipse in color. According to Dr. Jean Xantakis of Thessaloniki, totality lasted several seconds less than predicted; Baily's beads, too, lasted a shorter time and were not as extensive as at some earlier eclipses. Also at Hvar were astronomers from Meudon Observatory in France and two Yugoslav teams, from Ljubljana and Belgrade. The French used a coronagraph and two spectrographs; our parties had a 20-cm. refractor and a spectrograph.

About 40 amateurs from Zagreb chose an old fortress overlooking Hvar for their eclipse site. They had two Zeiss 10-cm. refractors and five small satellite-tracking scopes, to determine contact times. On the opposite side of the island were some of the 120 members of the amateur and professional Astronomical Society of Croatia, founded in 1954. Their major instrument was a 22-cm. coelostat and telescope brought from their new solar observatory on the outskirts of Zagreb. In

Right: During all phases of the eclipse, these members of the Zagreb University eclipse team measured the intensity of solar radiation directly, using the photocell which is clamped to the bench.



Left: Taken six seconds after the photograph of the middle corona reproduced above, this two-second exposure shows the flat-hatted formation characteristic of the corona during the February 15th total eclipse.



Co-ordinating air and ground observations, a group of Italian amateurs photographed the diamond-ring effect. Its brilliant sparkle at the left was caused by multiple reflections in the airplane's window, when Pierluigi Erizzo took this 1/1,000-second exposure. At the right, the ring of the inner corona stands out and the "diamond" is strongly exposed. S. Chierici, on the Italian Riviera, used a Leica camera and 40-cm. telephoto lens at f/8, for a 1/50-second exposure.

the interior of Hvar, on a hilltop about 1,800 feet high, the geophysical team of the University of Zagreb set up its camp, where the writer observed. We measured solar radiation and the influence of the eclipse upon air temperature and atmospheric electricity. Contacts were timed from a projected image of the sun.

The eclipse itself seemed unreal, especially the appearance of the corona. Just before second contact we noted shadow bands on the ground. The altitude of the sun at mid-eclipse was about 17 degrees. To the west shone Jupiter and Saturn, close together in the sky as they approached their conjunction three days later. Bright Venus appeared low in the east, while Altair twinkled on the meridian.

MIROSLAV KOLAK
Bijenicka 7
Zagreb 1, Yugoslavia

Nis, Yugoslavia

In order to test basic instrumentation for geodetic great-circle determinations during future solar eclipses, a project was proposed by Klemens Nottarp, of the Frankfurt Institute of Applied Geodesy, and carried out in co-operation with the Geodetic Institute of the Technical University of Belgrade. Our site was on the side of a hill near Nis, about a mile south of the predicted central line of totality.

We had apparatus to receive radio time signals, two chronometers, and a photoelectric photometer to measure the light intensity of the eclipsed sun and the sky around it. For comparison, and to record the passage of the lunar shadow cone at contacts 2 and 3, we planned measurements with a photometer having a 140-degree field centered on the zenith. All our data were recorded on magnetic tape.

I intended to observe the planet Mercury in hydrogen-alpha light, using interference and polarizing filters and photographic overexposures. If Mercury has a magnetic field, its interaction with the interplanetary extensions of the solar corona might cause it to have a dense belt of charged solar particles. This could possibly be observed as a faint source of scattered sunlight in the vicinity of the planet's illuminated crescent.

About 30 minutes before totality, the sun came out of the clouds and was visible for some time. But a dense layer of fog hid Mercury from view. Thus, the Belgrade observers carried out their program as planned, but I could only watch the eclipse itself.

REINHOLD GERHARZ
8703 Burdette Rd.
Bethesda 14, Md.

Genoa, Italy

Several Italian amateurs, including the undersigned, joined forces to photograph the eclipse in black and white and color from the Italian Riviera and through the windows of an airplane chartered by members of the Swiss Astronomical Society.

Color pictures taken from the ground have markedly warmer tones than those obtained in the air. To guard against effects of aircraft vibration and movement, the long telephoto lenses were supported from the operator's body by means of special attachments, allowing exposure times as long as 1/60 second.

With a focal length of 40 centimeters, at f/8 on black-and-white film rated ASA 80, a one-second exposure recorded the corona up to 1.5 solar radii from the limb, not counting streamers. With the same focal length at f/5.6, the corona up to 0.7 radius was obtained on ASA 160 color film at 1/60-second exposure.

The inner corona to 0.1 was caught, together with solar prominences, on a $\frac{1}{4}$-second, f/17 exposure taken with a lens of 142-cm. focus. From both the air and the ground we secured rather striking pictures of the diamond-ring effect, reproduced above.

PIERLUIGI ERIZZO
2 Piazza Corvetto
Genoa 125, Italy

Nice, France

A graduate student in astronomy at Indiana University, I undertook a personal expedition to the French Riviera to observe the eclipse, obtaining several photographs from 1,100-foot-high Mt. Gros, outside Nice.

My equipment was placed on a mounting of my own design combining a pair of 7 x 50 binoculars with a 75-mm. twin-lens reflex camera. A 7 x 35 monocular was used as a viewing telescope. The exposures on Super Anscochrome during totality were $1\frac{1}{2}$ seconds long at an effective focal ratio of f/11.

The original transparencies show both the faint polar streamers and the longer equatorial coronal extensions typical of a time of intermediate sunspot activity, but it is difficult to transfer these details to black-and-white negatives.

KENNETH C. LEONARD, JR.
Indiana University
Bloomington, Ind.

Proctorville, Ohio

As in the past, I monitored selected radio stations during the total phase of the eclipse to study radio-wave propagation at such times. Using crystal filters and several receivers, it was possible to cover 12 different channels during the time that the moon's shadow was sweeping across Europe and Asia.

Prior to February 15th, the same equipment was used to select the wave lengths and to chart the signals normally received.

(Continued on page 211)

A view of the Ottawa mirror transit from the northeast. The meridian extends from right to left, the building that covers the northern collimator telescope having been rolled back out of the picture to the right. At the eye end of the collimator is a control console on casters, and a technician stands at the 10-inch objective. Behind him is one of the two fixed buildings that cover the east-west ends of the central-mirror mounting, with associated 3-inch pivot telescopes and declination-circle reading mechanisms. At the left is the southern collimator's building. All this article's illustrations are from Dominion Observatory, Canadian Department of Mines and Technical Surveys.

The Ottawa Mirror Transit Telescope

G. A. BREALEY, *Dominion Observatory, Ottawa, Canada*

ACCURATE determination of star positions is obviously of great importance in astronomy, yet this work is carried on at relatively few observatories. These are mostly government-operated national institutions, such as the U. S. Naval Observatory, the Royal Greenwich Observatory, and the Dominion Observatory here in Ottawa, Canada. The star-position programs are conducted continuously, receiving little notice, with a modest-size instrument.

Recent years have seen a great increase in the usefulness of fundamental stars — those whose positions are known with greatest accuracy. They are necessary in many fields: stellar proper motions, planetary positions and motions, celestial navigation, and missile guidance systems, to name just a few. It is very desirable, therefore, that our position-determining instruments be refined to achieve higher accuracy than in the past.

The standard observatory instrument for finding accurate star positions is the transit circle, invented at the beginning of the 18th century by the Danish astronomer Olaus Roemer. It consists of a telescope mounted on a horizontal east-west axis to sweep the meridian from north to south. The vertical angle of the telescope's pointing is indicated by a graduated circle that turns with it. From the reading of this circle, a star's declination (angular distance north or south of the celestial equator) can be deduced.

Because the transit circle is restricted to the plane of the meridian, we must depend on the earth's rotation to bring stars into the field of view. Each star's right ascension — its place within the 24 hours of rotation — is then found from the instant the star is on the meridian, by means of an accurate clock.

In the field of view are crosshairs which enable the pointing of the telescope in declination and the time of meridian passage to be determined with precision. The principal improvement to Roemer's design has been to provide a movable wire in the field of view, with an automatic registering device that records several positions of the star during meridian passage. Other improvements, such as photographic registration of the circle settings, have further increased efficiency.

A modern transit circle of standard de-

sign is our 6-inch instrument pictured below. On the axis that carries the telescope are two graduated circles three feet in diameter, one of which indicates the pointing of the tube from the record of four cameras on the left (east) pier. Once a month the instrument is reversed in its pivots, bringing the other circle, clamp, and vernier adjustment to the left side, while the large spoked setting ring moves to the right.

Felt and wood insulation on the piers reduces thermal fluctuations within them. Small hand wheels move the eyepiece so that the cross wires may bracket the star in its motion across the meridian. By the same motion a contact wheel is driven to record the time of meridian passage.

For several decades, the mean error of a single observation made with this transit circle, as well as with similar instruments at other observatories, has remained about 0.35 second of arc. By contrast, the mean error for a photographic zenith tube is 0.10 second. But a "PZT" is a completely fixed instrument which can observe only stars that pass overhead at its location, for time and latitude measurements.

The conventional transit circle's lower precision results from several inherent weaknesses: tube flexure, instability of the micrometer slide in zenith pointing, and thermal disturbances due to the observer being close to the telescope. In addition, the Ottawa instrument suffers from its location within the heavily walled transit room with its narrow slit.

Therefore, when it was decided in 1953 to replace the Ottawa transit circle, we turned to the idea of the *mirror transit,* suggested by H. H. Turner in 1894 and recently explored in detail by R. d'E. Atkinson of Greenwich Observatory. Like the transit circle, the mirror transit is capable of fundamental measurements of star positions. The relatively large telescope is replaced by a mirror, which adds another optical component but reduces the weight of the parts borne by the axis. The new design permits completely photographic registration and remote control by servomechanisms.

Now nearly finished, our new mirror transit consists of two rigidly mounted horizontal 10-inch f/16.8 refractors, pointing toward each other and spaced about 15 feet apart on a north-south line. Centered between them is a flat mirror that directs starlight to one or the other telescope. This mirror, 11 inches in diameter and two inches thick, is made of fused quartz, which has thermal properties greatly superior to glass. It is mounted on an east-west axis 36 inches long. The pictures on the facing page give details of the mirror's mounting and the circle-reading devices.

Unlike mirror transits that are now being constructed in England and Portugal, ours has the axis of rotation coincident with the surface of the mirror instead of with its center of mass. To achieve this, two weights located immediately outboard of the mirror counterbalance it and the massive metal cell. The mirror rests in its cell on three lead-topped brass studs, and is held down by three opposing pressure pads, 120 degrees apart around the rim. In addition, two fixed studs and a spring-loaded plunger hold the mirror by pressure on its sides within the cell.

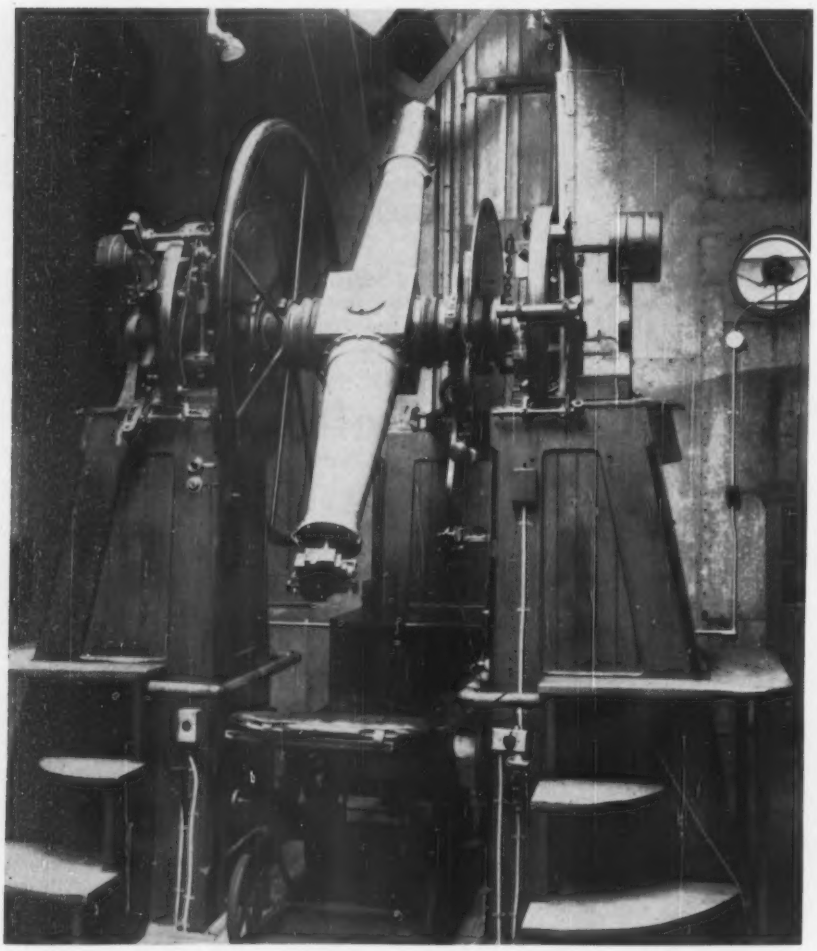
The central mirror assembly is mounted as carefully as is the usual transit telescope. Most of the weight is relieved by the cantilevered counterpoises (white at top of pictures) similar to the ones on the 6-inch instrument. The remaining 20-pound load at each end of the axis assures proper seating on the pivots with negligible wear.

Thus we see that the major advantage of the mirror transit over conventional instruments is that a heavy telescope pivoted at its center is replaced by a relatively light mirror. Each stationary telescope is free from differential flexure, and massive components can be added to the objective end or the eye end as required.

The success of the new instrument will depend upon the accuracy with which the mirror adjustments are known. Several ways of checking them are provided. The mirror may be turned to the north and to the south for autocollimation of the 10-inch telescopes. Each of those instruments may observe autocollimation in a mercury basin by turning the mirror 45 degrees downward both north and south. The axis can be reversed in its pivots and these operations repeated. Finally, these tests may all be compared to the results of collimating the north telescope on the south one directly with the mirror hoisted out of the way.

Besides the preliminary squaring-up adjustment of the axis to the line of collimation, these measures indicate the angle that the mirror normal makes with the axis of rotation. But is this angle the same for all orientations of the mirror? To study this uncertainty, side mirrors are attached to the main mirror with their faces perpendicular to its surface and parallel to each other within a few minutes of arc.

These side mirrors face out through the hollow pivots and may be examined by pivot-testing telescopes which are three

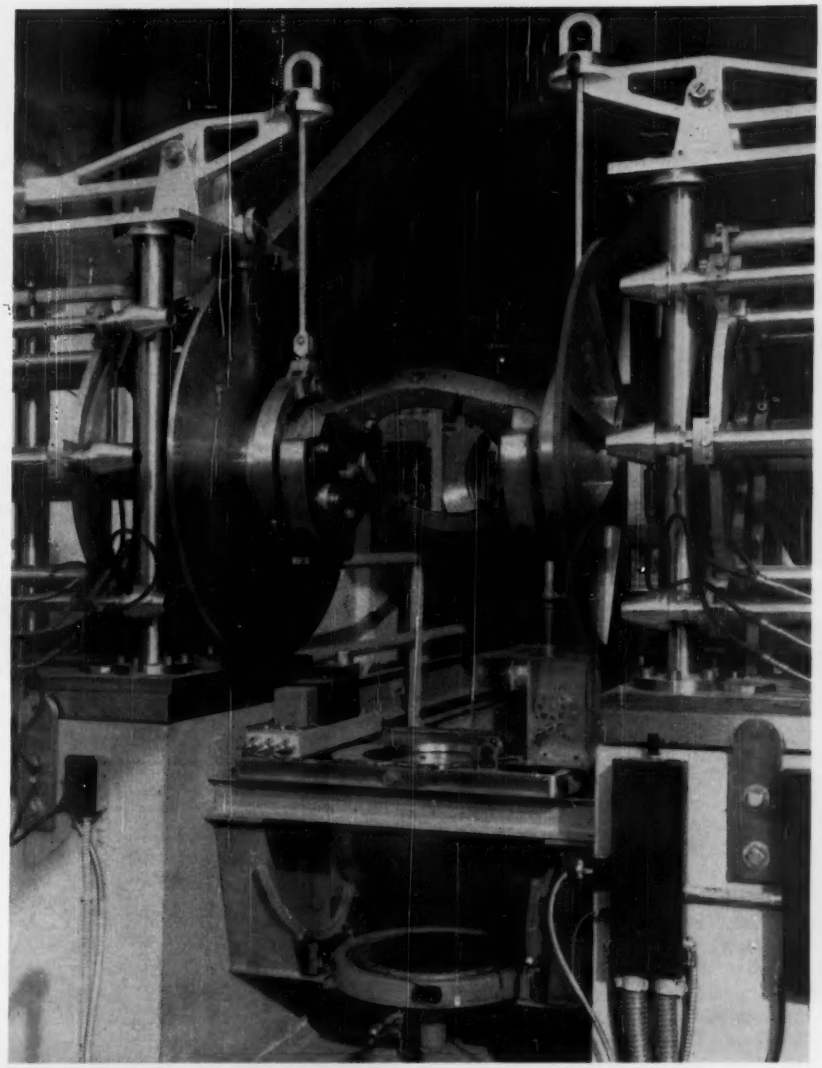


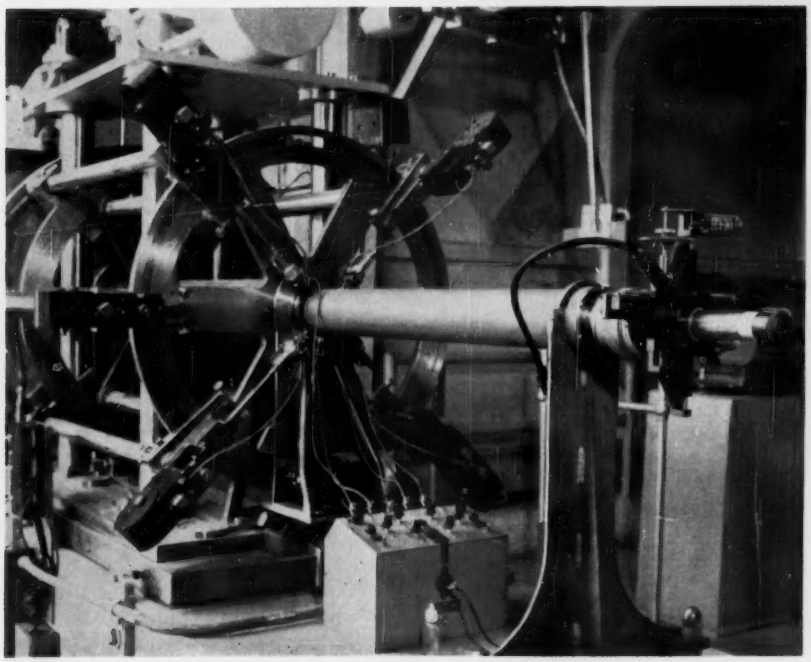
The old Ottawa meridian circle has a 6-inch objective lens of 85-inch focal length. Beneath the instrument is the observer's couch, and at top center is a part of the slit that is opened for observing.

inches in aperture and 72 inches in focal length. These two instruments lie horizontally on either side of the central assembly, extending in an east-west direction. A reticle at the eye end of each telescope is compared with its autocollimated image by a measuring engine, the smallest unit of which corresponds to a linear displacement of 0.00001 inch, or 0.25 micron. Theoretically, with this apparatus we should be able to determine the side-mirror positions to about 0.03 second of arc, which indicates the control available in tracing the normal to the main mirror.

Attached to the mirror axis are two large circles, one toothed for motor control of the mirror setting, the other graduated at intervals of three minutes of arc for recording mirror orientation. The angle of tilt of the mirror is determined by photographing the graduations of this declination circle with a battery of four or six cameras. All parts on one side of the central mirror assembly have to be duplicated on the other, for use when the assembly is reversed in its pivots, just as with a transit circle.

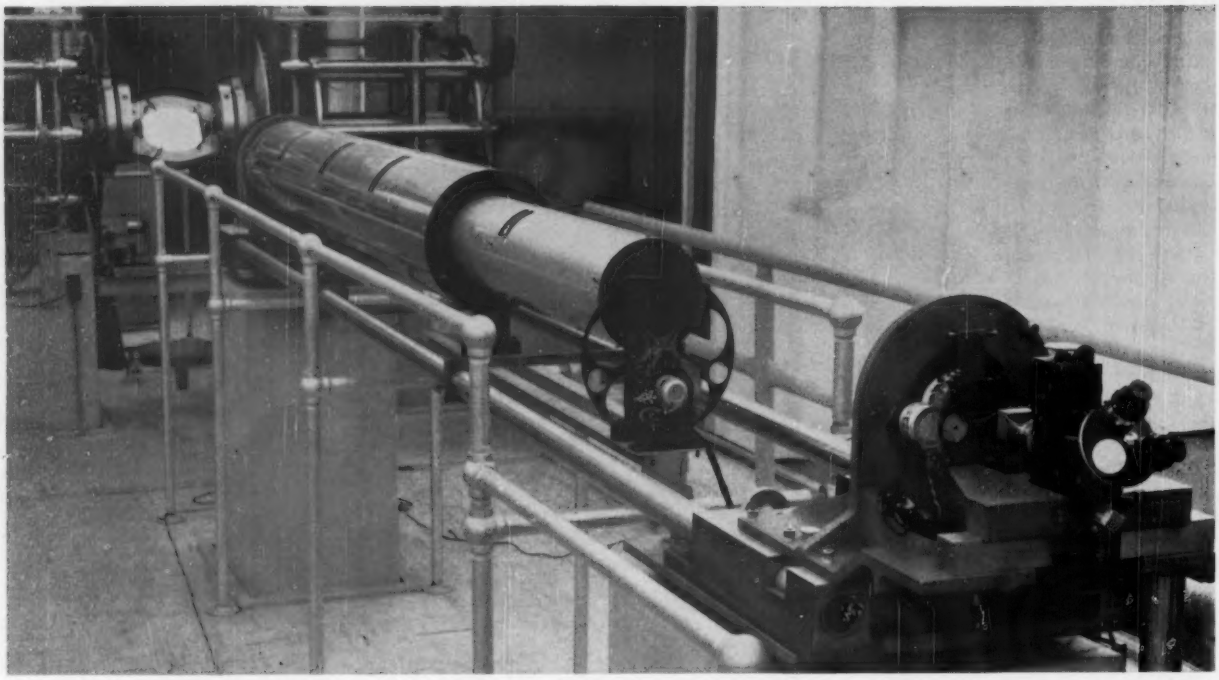
How the mirror transit is used can be seen on page 208 in the diagram of its optical system. The mirror is set so that light from a selected star is reflected into the objective lens of the north or south collimator telescope. The light passes through one of four screens, selected to dim the star to within a narrow range of apparent brightness. For very faint stars, no screen is used. Next is a plane-parallel plate, $\frac{3}{8}$-inch thick, which can be tilted by a measurable amount around an east-west axis in order to displace the light beam vertically. It is used in visual observing to provide a micrometer measure in declination, in place of the eyepiece





Above: The central portion of the new mirror transit, the east-west axis extending to the right and left. The 11-inch mirror is pointing downward at 45 degrees for alignment of one of the 10-inch collimators with the mercury horizon (black pool) at the bottom of this picture. The main mirror has flattened sides to provide for fastening small mirrors used with the 3-inch-aperture pivot-testing telescopes. The circle-reading microscope objective ends are seen here, the graduated circle being at the left.

Left: Looking toward the central assembly from the side, showing the circle-reading microscopes with cameras and one of the 3-inch pivot telescopes. The control box provides switching and automatic cycling of the circle photography. Film advance is effected by small magnetic clutches, their inputs being driven by the motor behind the control box.



At upper left, the main mirror is pointing upward about 45 degrees, so it will reflect light from a star near the zenith into the collimator, whose objective is at the far end of the tube. The latter is often called a "light pipe," for it is supported independently of the 10-inch lens. At the near end of the tube is a rotating screen selector. The gap between it and the eyepiece assembly will eventually be occupied by another light pipe.

filar micrometer of a conventional transit circle.

The star image comes to a focus at the right-hand face of the fixed reticle, which is etched with the pattern shown in the diagram. This reticle is the only one used for photographic registration. Its central vertical line is the fundamental datum in right ascension. The three horizontal lines provide several references for measurement of the declination co-ordinate.

The next component in the optical path is a moving reticle, with an etched pattern on its left face, which is only 0.0015 inch from the fixed reticle, so that both patterns are simultaneously in focus with the star image. The moving reticle, together with all the parts inside the dashed box in the diagram, is shifted in right ascension at controlled sidereal speed during a visual observation. This second reticle is not used in photographic work.

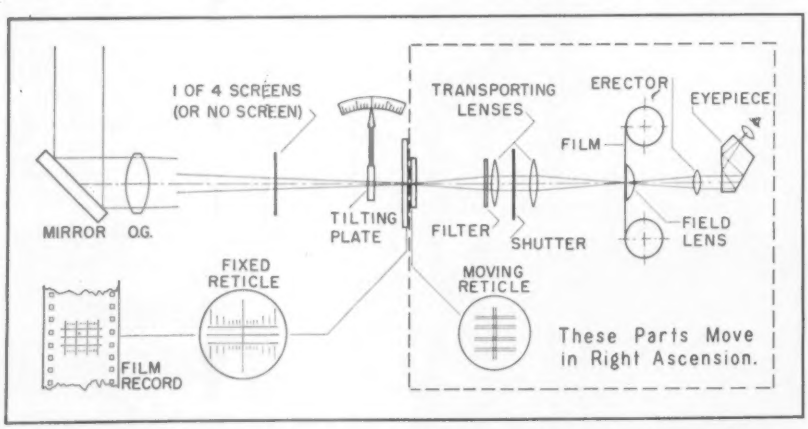
As the diagram shows, transport lenses transfer the star and reticle images, unchanged in size, to the film. The camera always remains in position, so for visual observing a hole is punched in the film. Additional lenses and a prism bring the eyepiece to a convenient position. The fixed reticle is illuminated by a flash tube. In photographic work, only this reticle is used, the intermittent flashes causing its image to be recorded several times on a film frame while the exposure on the star is being made. As the instant of each flash is known and the film moves at sidereal speed with the star, the stellar image is located in space and time with respect to the images of the reticle. For visual work both reticles are illuminated by incandescent lamps of controlled brightness.

When transits are observed visually, the cameras remain in position, thus not altering the loading of the mounting. For photographic purposes, the camera's eyepiece is either covered or turned away to seal off light from the film.

The many cameras employed in the mirror transit are of our own design; they record the declination circle setting as well as the position of the star during transit. Each camera's magazine can hold about 120 feet of 35-mm. film, and a removable cassette will store a night's work up to 160 frames. In order to focus a camera, a $\frac{1}{4}$-inch hole is punched in the film and advanced to the focus frame, where it is examined with an eyepiece.

For the circle-reading cameras, we use high-contrast low-sensitivity film of microfile quality; these records will be measured in an automatic photoelectric engine and the results recorded directly on punch cards for later high-speed data processing. The 35-mm. film used in the 10-inch telescopes is fast panchromatic, such as Plus-X, sensitive in the photovisual range, 5100 to 6000 angstroms, in which we observe. As the optical diagram shows, a filter is inserted to pass only wave lengths longer than 5000 angstroms.

The Ottawa mirror transit is housed in a four-part building of steel-frame construction, sheathed with asbestos siding and insulated with a two-inch layer of asbestos wool. In summer, two air conditioners cool the building by day, in antici-

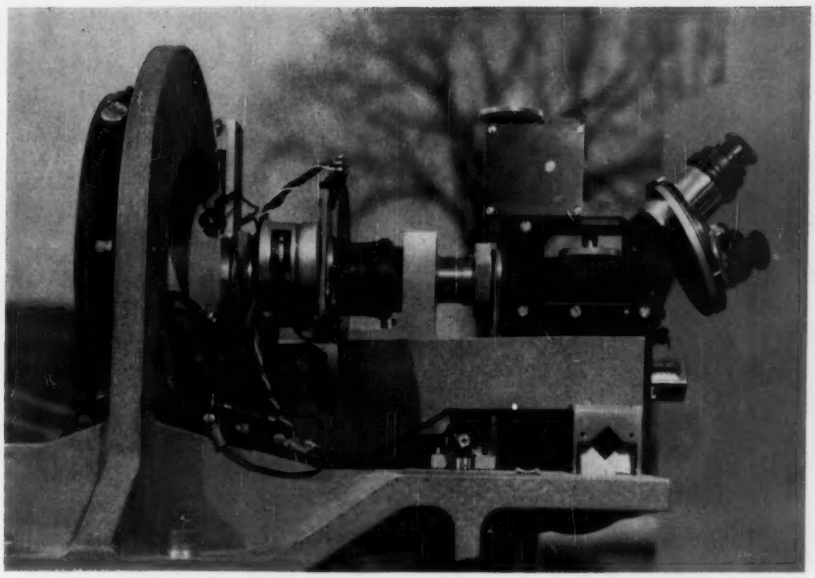


A schematic diagram of the mirror transit optics. The fixed-reticle markings are shown, but some very small numbers on it have not been reproduced.

pation of nighttime temperatures. As pictured on page 205, the two main sections of the building move to the north and south along tracks, and permit observations down to 13 degrees above the north and south horizons.

The sheltered control room, east of the center section, contains servomechanism controls for operating the instrument, and there is an additional set of controls at each collimator telescope's eye end. The servomechanism is a coarse-fine error-signal generator, and the transmitted positions are relayed to the telescope plate-drive mechanism, where they are translated into speed of driving the camera and film, length of exposure, and spacing of timing contacts. The selfsame positions are relayed also to the receivers that turn the mirror on its axis.

Preliminary tests show that this mirror transit will provide an important forward step in positional astronomy. Although the controls at the two eye ends are not complete, hand-guided test exposures have given good star images, demonstrating that servomechanism control of the mirror is positive and accurate. Stars as faint as the 11th magnitude are observable. We hope that a regular observing program will be under way by the fall of this year.



Details of the telescope eyepiece assembly. A portion of the bakelite enclosure for the fixed reticle is seen at the extreme left. One of the two transport lenses is hidden behind the motor of the shutter mechanism. The camera unit and turret eyepiece are at the right. At the bottom the lead screw shaft can be seen and to its right the dark "diamond" is formed by the V grooves in which ball bearings run to permit sideways motion of the eyepiece-camera assembly in following the star being observed. As viewed here, this motion is in and out of the plane of the paper.

QUESTIONS... FROM THE S+T MAILBAG

Q. What are the faintest and brightest supernovae recorded to date?

A. In 1950, a supernova appeared in the galaxy NGC 4051 in Coma Berenices that attained only apparent magnitude 17.7 at maximum. The brightest was Tycho's star of November, 1572, in Cassiopeia. It briefly rivaled Venus in brilliance, and was seen in broad daylight.

Q. I want to construct a scale model of the orbit of Halley's comet. What are its orbital elements?

A. The orbit is an ellipse of eccentricity 0.97, semimajor axis 17.9 astronomical units, and perihelion distance 0.59 a.u. The orbital plane is inclined 162° to the ecliptic; longitude of ascending node, 57°; argument of perihelion, 112°. The period is 76 years, and the last perihelion passage was in May, 1910.

Q. What is meant by a small, medium, or large amateur telescope, in connection with lunar and planetary observing?

A. Usage varies, but generally a small reflector is of 6-inch aperture or less; medium indicates a mirror diameter of eight or 10 inches; while a reflector of 12-inch or more aperture would be called large. For refractors, a 4- to 6-inch aperture can be regarded as medium, 8-inch or over as large.

Q. How can I find the diameter of an eyepiece's field of view in my telescope?

A. One very simple method is to time how long it takes a star near the celestial equator to drift from one side of the field through the center to the other, the telescope being kept stationary. Divide this time interval in seconds by four to obtain field diameter in minutes of arc.

Q. Is it possible that another planet is traveling in the earth's orbit that has never been seen because it is always on the other side of the sun from us?

A. No such planet of appreciable size exists, for it would have made its presence known by causing gravitational changes in the orbits of Mars and Venus.

Q. How much meteoritic material lands on the earth's surface per day?

A. About half a ton, according to F. G. Watson, but there is a considerable range among the estimates of experts.

Q. What is the smallest telescope that can show visually the North America nebula in Cygnus?

A. It has been seen with apertures of six inches by Leslie Peltier, Delphos, Ohio, and by Walter Scott Houston, author of the Deep-Sky Wonders column in this magazine.

Q. Why does a star being occulted by the moon vanish behind different points on the lunar edge, as observed from two widely separated geographical locations?

A. This is a parallax effect, caused by the fact that the moon is very much nearer than the star. A similar phenomenon can be seen by viewing, first with one eye and then the other, a pencil held at arm's length in front of a distant background.

W. E. S.

OBSERVING THE SATELLITES

(Continued from page 201)

far south of the equator, this time near latitude −40° for 1961ζ.

Discoverer XXI, like an earlier member of the series, XIX, was not equipped with a re-entry capsule. It was designed to gather engineering and research data on atmospheric phenomena and infrared radiation, in support of the Midas program for the detection of missile launchings. During its first two days in orbit, Discoverer XXI telemetered such data to four ground stations.

TRANSIT III-B LAUNCHED

FEBRUARY, 1961, was already established as the busiest month yet for artificial satellites before the sixth and final launching placed a 12th object in orbit. This was 1961η, launched from Cape Canaveral on February 22nd at 3:45:04 Universal time. Actually, it consisted of three parts intended to have independent orbital careers. However, the Able-Star rocket failed to separate from the Navy's Transit III-B navigational satellite, which in turn remained attached to Lofti, the Naval Research Laboratory's smaller, low-frequency radio experiment.

Initially, the orbit was inclined to the earth's equator by 28°.37. Apogee and perigee were 618 and 106 miles above the surface, respectively, while the period from perigee to perigee was 96.32 minutes.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 107th meeting of the American Astronomical Society at New York City, December 28-31, 1960. Technical abstracts will appear in the Astronomical Journal.

Local Doppler Effects in the Photosphere

The granular structure of the sun's surface, shown so beautifully in Project Stratoscope photographs (SKY AND TELESCOPE, December, 1959, page 79), is a visible indication of convection and turbulence in the solar atmosphere. Since such turbulence usually involves motions along our line of sight, small Doppler shifts should be detectable in the absorption lines of the solar spectrum, if the latter is observed with high dispersion and under really good seeing conditions.

A spectral line is actually an image of a narrow strip of solar surface at a particular wave length. The turbulence within the strip will cause some solar material to move toward us for a while, as adjoining material moves away. Light from the approaching portion will be Doppler-shifted toward the violet end of the spectrum, that from receding matter toward the red. These differences from point to point along the strip produce fine "line wiggles," which because of the turbulence are constantly fluctuating.

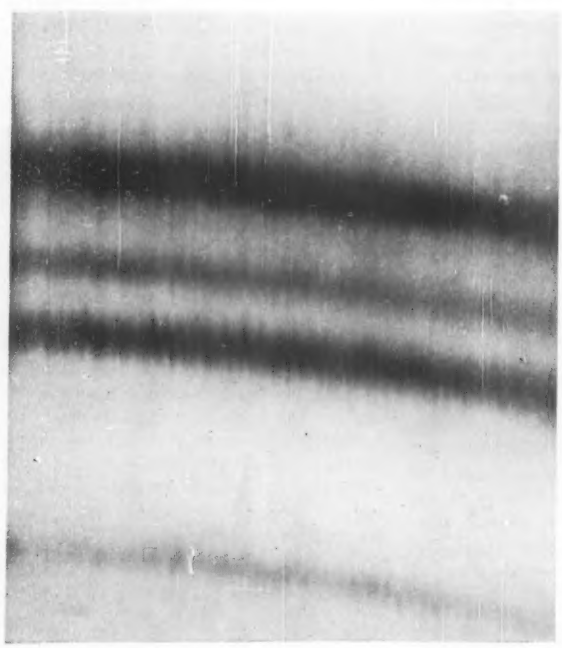
Such wiggles have, in fact, been well observed during the past 10 years by R. S. Richardson and M. Schwarzschild, by the McMath-Hulbert observers and others. However, these observations have shown the velocity structure of the photosphere at some fixed time, without revealing anything about the persistence of upward or downward motion at any one point on the solar disk.

At the New York meeting, J. W. Evans and H. A. Mauter, of Sacramento Peak Observatory, U. S. Air Force, showed a motion picture of the line wiggles. Its frames were taken at successive five-second intervals for a total time of two hours, recording changes in the lines of neutral iron and chromium near 5328 angstroms in the green. A single-frame enlargement is reproduced here. In addition, 31 spectrograms of the neutral iron line at 5324.2 angstroms were taken at 20-second intervals.

When the film is projected, the compressed time scale reveals a generally random change in the Doppler effect at any point on the sun, three or four minutes being usually required for a velocity maximum to develop and decay. A typical maximum velocity is about 0.6 kilometer per second. Several instances of apparently periodic alternations in direction of motion were recorded, but this may be no more than an accidental pattern. In any event, the observations seem to indicate displacements of material through heights of 50 or 60 kilometers.

Studies of the 31 iron-line spectrograms give 3.5 seconds of arc for the average length of a turbulent element along the spectrographic slit, which corresponds to about 2,000 kilometers on the sun. Since the lines originate in a layer perhaps 200 kilometers thick, the actual motions seem fairly small compared with the dimensions of the moving elements themselves.

Dr. Evans pointed out that this work concerns only the relatively large-scale aspects of photospheric turbulence, which probably includes lesser motions of material elements too small for telescopic resolution.



One of the frames of the Sacramento Peak Observatory's film of wiggles in solar absorption lines. The uppermost line (neutral iron) is at 5328 angstroms. The direction of the spectrograph slit is horizontal on the page, with violet toward the top and red toward the bottom. Upward wiggles in the lines are caused by Doppler shifts toward the violet (motions of approach), downward wiggles are redward shifts caused by receding material. The horizontal scale is about five seconds of arc per millimeter, and the sun's edge is toward the right. Photograph courtesy Air Force Cambridge Research Laboratories.

X-Rays from Collisions of Stars

A rare, extremely violent type of stellar catastrophe was predicted in a paper presented by S. N. Milford, of St. John's University. This is the collision of two stars with high relative velocities, of the order of 2,000 kilometers per second, an event which is possible when two galaxies collide. In such an encounter the two stars could slice each other apart without much distortion, leaving two partial stars and considerable debris. The sudden exposure of the hot stellar interiors would release a tremendous flood of radiant energy.

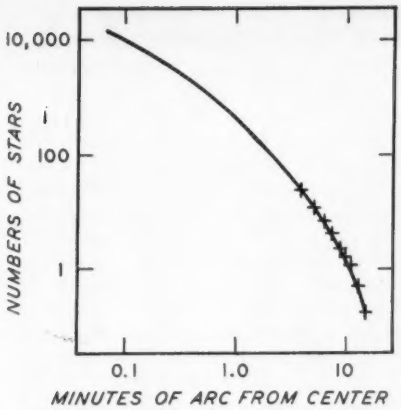
He has made detailed calculations on the simplifying assumption of a star sliced exactly into hemispheres. A dwarf *K*-type star, so divided, would become 10^{10} times as luminous as the sun, a *B*-type star 10^{14} times. This energy will be mainly in the form of X-rays, with maximum intensity at a wave length between 2.0 and 6.5 angstroms. But as the stellar fragments expand and cool, the radiation will rapidly fade, and the peak will shift to longer wave lengths.

These disasters must be exceedingly rare, for galaxies collide infrequently, and their stars are so thinly spaced that one stellar system may simply pass through the other with no star collisions at all. Dr. Milford estimates that one such *B*-star collision may occur every thousand years within a spherical volume of three billion parsecs radius. Collisions of stars in single galaxies within the same volume occur much more frequently, but most of these are much too slow to release comparable amounts of energy.

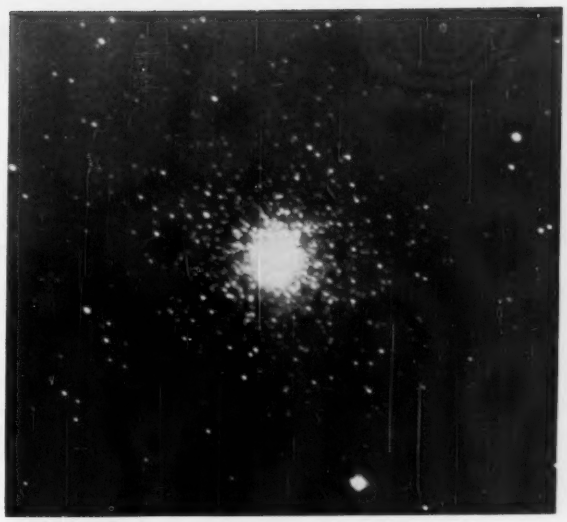
Globular Cluster Densities

The tens of thousands of stars in a rich globular cluster are densely packed at its center and thin out with increasing rapidity toward its edges. For studies of globular-cluster origin and evolution, it is important to establish the mathematical law describing the projected star density in a cluster, that is, the rate at which the number of stars per unit area decreases from the center outward to the edge.

Though this problem is an old one, modern instruments permit more extensive star counts, warranting new studies. Recently, Ivan King, University of Illinois Observatory, was a guest investigator at Mount Wilson and Palomar Observatories, where he made a thorough analysis



Left: In Ivan R. King's plot of projected star density for the globular cluster M15, the crosses show his counts on a maximum-exposure 48-inch Schmidt plate.



Right: This 20-minute exposure of M15 was made by Dr. King on the morning of July 3, 1948, with the 61-inch Wyeth reflector at Harvard's Agassiz station. The scale in this enlargement of a section of the original plate is about $4\frac{3}{4}$ minutes of arc per inch. South is at the top.

of star densities in Messier 15, the bright globular in Pegasus. This cluster has a small central core and an extremely high central concentration, making it a severe test for any empirical density law.

Dr. King combined star counts and photoelectric surface photometry to derive the star distribution from the core to the very edge of M15. For the innermost, unresolved parts he measured surface brightness photoelectrically with the Mount Wilson 60-inch reflector, and combined these results with similar measures over a larger area made at Lick Observatory by G. Kron and N. U. Mayall. For the outer parts of M15, he counted star images on seven plates taken with the 60-inch and 100-inch telescopes and with the Palomar 200-inch reflector and 48-inch Schmidt telescope.

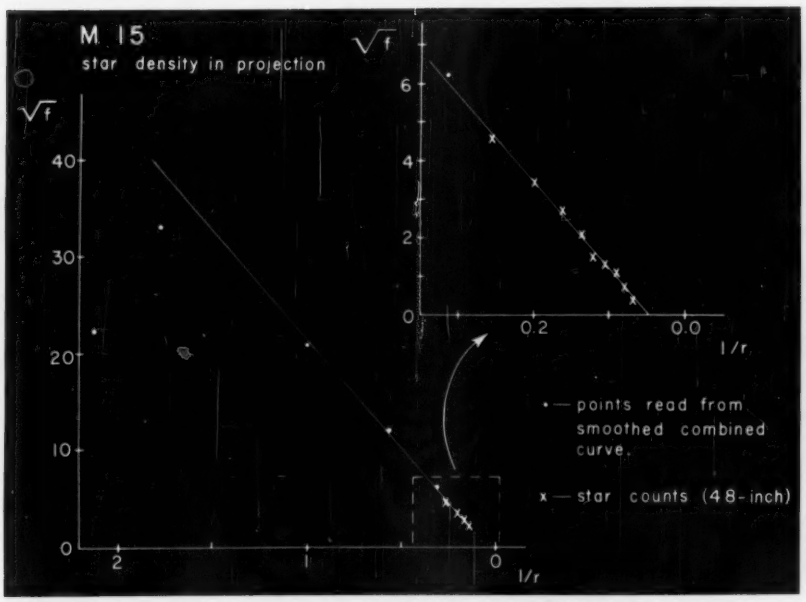
The Illinois astronomer presented the star frequency curve plotted above to show that the density in the outer parts of a globular cluster does not vary as the inverse fourth power of the distance, r, from the center, as has been widely believed. Such a simple power law would appear as a straight line on this logarithmic chart, whereas the stars thin out even more rapidly near the edge of the cluster.

Dr. King finds that the square root of the density is proportional to the value of $1/r$ minus $1/r_0$, where r_0 is the limiting distance to the actual edge of the cluster. His plots of the observations, seen below for the cluster as a whole and in detail for its outermost parts, show how this law holds for all but the innermost region. The observed points lie on a straight line, and its intercept with the horizontal axis gives r_0, the limiting radius of the cluster.

Theoretically, there should be a limit to the radius of any particular globular, imposed by the disrupting action of the tidal force of the Milky Way galaxy as a whole. For M15, the tidal limit can be roughly estimated as 25 minutes of arc, agreeing well with the limiting radius r_0 = 21 minutes, indicated by the chart of Dr. King's star counts.

He made additional tests of the formula, finding that it gives a good fit to published measurements of surface brightness in the bright southern globulars Omega Centauri and 47 Tucanae, as well as to his own star counts in the Hercules cluster M13.

Dr. King points out that for very large systems his formula becomes the same as one proposed by E. P. Hubble for the density in the outer parts of spherical or ellipsoidal galaxies.



The square root of the projected star density is here plotted against the reciprocal of the distance from the center of the cluster in minutes of arc. The smaller graph is a detailed view of the section outlined by dashes, and shows the intercept that gives the limiting radius.

REPORTS FROM FEBRUARY ECLIPSE OBSERVERS

(Continued from page 204)

There was some difficulty in selection because of interference from all-night broadcasters here in the United States, but by choosing relatively low frequencies most of them could be avoided and at the same time powerful transmitters in Europe could be received.

Among the stations chosen were those in Nancy, France, at 836 kilocycles per second; Rome, Italy, 845 kilocycles; Rostov-on-Don, U. S. S. R., 674; and Bucharest, Romania, 854.

At first the signals came from the east, but at 8:23 Universal time the direction changed and for the remainder of the eclipse they came from the north and northwest. This change was particularly noticeable at 674 kilocycles.

My measurements were made with a meter which was read visually; earphones were used to confirm the source of the signal causing meter deflection. Details of the observations will be submitted to a radio publication.

DAVID F. THOMAS
Box 1613
Proctorville, Ohio

NEWS NOTES

VAN ALLEN BELT PRODUCED BY NEUTRONS

The source of the particles forming the inner Van Allen radiation belt has been established by Wilmot Hess of the University of California. Two experiments, described before the American Physical Society, have shown that the belt is populated by decay particles from neutrons leaking out of the earth's atmosphere.

The experiments consisted of neutron counters carried aloft by Atlas rockets, one under normal conditions, the other during an intense solar storm. They demonstrated that the number of neutrons increases during such solar activity, probably because of greater numbers of solar protons smashing into atmospheric oxygen and nitrogen nuclei.

Dr. Hess believes that neutrons are produced continually by this mechanism in amounts sufficient to cause the observed radiation belt, after they escape from the atmosphere and decay into protons and electrons. It is these charged particles, trapped by the earth's magnetic field, that actually make up the inner Van Allen belt.

SUPERNOVA IN MESSIER 85

H. S. Gates at Palomar Observatory and L. Rosino at Asiago, Italy, have independently discovered a faint supernova in Coma Berenices. It is located about two minutes of arc south of the nucleus of the elliptical galaxy Messier 85 (NGC 4382), which has the 1950 co-ordinates $12^h\ 22^m.8$, $+18°\ 28'$.

This exploding star was detected by the California astronomer on January 15th, and by Dr. Rosino three days later. Palomar photographs indicate that the supernova was fainter than magnitude $17\frac{1}{2}$ last November 20th, but by December 20th it had brightened to 12. When the new object was recognized in mid-January, it had faded to 14. Its spectrum has been observed at both Mt. Palomar and Asiago, but descriptions disagree.

GREEN FLASH

A phenomenon associated with the green flash was observed on March 28, 1960, by R. E. Seebold, U. S. Naval Research Laboratory, who writes in the February *Journal* of the Optical Society of America:

"Just prior to sunset a high-flying airplane produced a contrail several miles in length, with almost perfectly oriented east-west direction, over the western Washington, D. C. area. The initial beauty of this orange-red path in the almost cloudless sky first attracted my attention. After the sun had set, with respect to my ground position, the color remained in the contrail. As the sun set on the contrail the orange-red coloration was erased along the trail and was replaced by a blue-gray, but interposed between the red and the gray was a thin strip of green which raced westward on the trail. The time of passage was of the order of 1-2 sec and must represent the 'green flash' as might be seen by a string of observers positioned along the contrail's path."

GALACTIC CO-ORDINATES

The problem of determining the central plane of the Milky Way and the direction to the galactic center was discussed by Otto Struve in SKY AND TELESCOPE for October, 1958, page 611. A note on page 383 of the May, 1959, issue described the new system of galactic co-ordinates adopted by the International Astronomical Union. Readers who desire fuller details should consult the series of five papers by Australian and Dutch astronomers in a recent issue of the *Monthly Notices* of the Royal Astronomical Society (Vol. 121, No. 2, 1960).

NEW NOVA SCUTI

A faint nova in the constellation Scutum has been discovered by M. Savelyeva, of the Sternberg Astronomical Institute, Moscow, on an objective-prism photograph taken with the 20-inch Maksutov telescope of the institute's Crimean station. A subsequent examination of direct photographs revealed that the new star was magnitude 12 in June, 1960, but fainter than 17 in 1950.

SUMMER COLLEGE PROGRAMS FOR HIGH SCHOOL STUDENTS

To stimulate the scientific interests of more than 9,000 students in secondary schools, the National Science Foundation has granted two million dollars to 158 colleges, universities, and research organizations. They will conduct summer programs in science and mathematics at higher levels than normally available in high school courses.

Astronomical studies are specifically listed at Emory University, Atlanta, Ga.; American Museum-Hayden Planetarium, New York, N. Y.; Agricultural and Mechanical College of Texas, College Station, Tex.; and Pan American College, Edinburg, Tex. Students now in the 10th through 12th grades are eligible, and should immediately contact the institutions they would like to attend for these summer courses.

A typical program is that of the Astro-Science Center of Pan American College, under Prof. Paul R. Engle. One course will be given in astronomy and astrophysics, another in astronautics and the space sciences. Nighttime observing will be stressed, using a 17-inch Newtonian-Cassegrainian reflector and lesser instruments. There will be Moonwatch alerts, studies of deep-sky objects, and observations of Jupiter and Saturn. It is planned to visit the high-altitude observatory being developed on Infiernillo Peak in Mexico.

IN THE CURRENT JOURNALS

A SEARCH FOR NEW OBSERVATORY SITES IN AUSTRALIA, by Bart J. Bok, *Journal* of the Royal Astronomical Society of Canada, December, 1960. "Statistics of night cloudiness at the favoured sites in New South Wales and Victoria show that conditions appear to be quite good, and we are already sure that a really satisfactory site for a Field Station for Mount Stromlo Observatory will be found."

THE CELESTIAL PALACE OF TYCHO BRAHE, by John Christianson, *Scientific American*, February, 1961. "In a tireless quest for accuracy Tycho filled his observatory with a succession of instruments, each more ambitious than the last. He recognized that by increasing the distance between the sights of his instruments, and by increasing the size of the calibrated arcs from which he read positions, he could gain accuracy. . . . He recorded that this great observatory at Hven cost Frederick II 'more than a tun of gold,' the equivalent of about $1.5 million today."

SURFACE EXPLORATION OF THE MOON, by Peter A. E. Stewart, *Spaceflight*, March, 1961. "The Moon is our nearest neighbour in space and will be the goal of the first expeditions to leave the Earth. At the present rate of scientific development, the first large lunar expedition could be mounted in 10 years. This paper outlines such a 10-year programme, examines the problems and some possible solutions and analyses a sample expedition."

X-RAYS FROM A SOLAR FLARE

When an orbiting satellite is within radio range of a receiving station, it may relay information about phenomena that are undetectable from ground locations because of atmospheric shielding. A particularly fortunate combination of circumstances placed satellite 1960η2 within range of the Blossom Point, Maryland, station during the eruption of a solar flare of importance 1 on August 6, 1960.

For the first six minutes of the 18-minute activity, satellite measurements of ultraviolet and X-ray intensities were relayed to earth. Following terrestrial radio fadeout, cosmic noise intensity decreased while the satellite measured an increase in the X-ray flux. Four minutes after the start of the visible flare, the sun began to emit a strong burst of radio noise at a frequency of 2,800 megacycles per second.

For its two-minute duration, the X-ray intensity rose to a very high level, which continued even after the radio-noise burst had disappeared. On the satellite's next passage, two hours later, there was no indication of abnormal emission. The sun's ultraviolet radiation, on the other hand, remained completely unchanged through the series of events.

ASTRONOMICAL SCRAPBOOK

The Reputation of Father Hell

A LONG TRAIN of consequences followed from a famous paper read by Edmond Halley in 1716 before the Royal Society of London, entitled "A New Method of Determining the Parallax of the Sun, or his Distance from the Earth." This paper explained how the sun's distance could be determined with vastly improved accuracy, by timing the beginning and ending of a transit of Venus across the disk of the sun as seen from widely separated places over the world.

This phenomenon had last occurred in 1639, when no useful observations of it were obtained. Consequently, astronomers awaited with keenest interest the next transits of Venus, on June 6, 1761, and June 3, 1769. Elaborate preparations were made and numerous expeditions set out for places as remote as Tahiti, Siberia, and California, in an international effort unprecedented in scientific history.

Of the many stories of these expeditions, one of the most curious concerns Maximilian Hell's 1769 observations in Lapland and their aftermath. This Jesuit astronomer was born in 1720 at Schemnitz, Hungary, and became one of the best-known astronomical figures of his generation. His order sent him to found a new observatory at Tyrnau in 1752, and three years later he moved to Vienna to take charge of the recently established university observatory. There he gained fame for his observations and writings, and especially for publishing 37 annual volumes of the Vienna astronomical ephemeris. Surely this useful career should have entitled him to a respectable if obscure niche in astronomical history.

He was long denied this, however, owing to a letter handed him on September 5, 1767, by the Danish ambassador at Vienna. It was an invitation from King Christian VII of Denmark and Norway to travel at royal expense to Vardo, in the extreme northeast corner of his domains, to observe the transit of 1769. This island station north of the Arctic Circle was of great importance, as observations of the transit made there could be combined with others from the South Pacific, to give a solar parallax determination of considerable weight.

Father Hell left Vienna on April 28, 1768, in company with his assistant, Johann Sajnovics, S. J. Their travel diaries, published many years later, give some curious details of their journey. One stop was at Znaim in Austria, where at the observatory they were shown an iron octant said to have belonged to Tycho Brahe. In Saxony, Sajnovics noted, the beer was so bitter that it could scarcely be drunk. The two traveled through Leipzig to Lübeck, where they were met by an agent of the Danish king and escorted to Copenhagen. Christian VII received them cordially.

The last leg of their travels was by ship to Vardo, where they arrived on October 11th to find a foot of snow on the ground. Erection of a small observatory began two days later; on the 18th their clock was set up, and the next day the first time-sights on the sun were taken. Hell's diary records trouble with the native helpers at the observatory, who would report for work at 9:30, take lunch from 11 to 2, and leave at 3:30, when it started to get dark. The remainder of the winter and spring were spent by the astronomers in geodetic surveys, observations of auroras, hunting, and enjoying the hospitality of the islanders.

On the date of the transit, June 3, 1769, the sun did not set in the high northerly latitude of Vardo. The ingress of Venus upon the solar disk was timed shortly after 9:30 p.m., through a brief break in the clouds, and the captain of the astronomers' ship fired off his nine guns and ran up his flag. The overcast remained solid until just before Venus left the sun about 3:30 a.m., when successful observations of egress were made, celebrated with another salvo.

The jubilant astronomers next day checked their clock correction by sun

Maximilian Hell, S.J. (1720-92). Titles on the books in the foreground symbolize the wide range of his work: algebra, magnetism, astronomical tables and ephemerides, the 1769 transit of Venus, the supposed satellite of Venus, and astronomical observations by missionaries to China. From a contemporary print, courtesy Owen Gingerich.

sights, and wrote letters to Vienna and Copenhagen, which were sent off by a courier armed with a flintlock. Father Hell and Sajnovics returned by sea to Copenhagen, arriving in late October, and spent the winter there.

Meanwhile, in Paris, the famous French astronomer Lalande was collecting all available timings of the transit in order to calculate the solar parallax. He wrote for Hell's observations, which the Vienna astronomer declined to furnish in advance of publication. This aroused suspicions, and Lalande hinted that Hell was waiting for other observations so that he could manipulate his own to fit them. There were even rumors that Hell had not seen the transit at all, and was forging his records in Copenhagen. Even though the publication of the Vardo observations by the Danish Academy of Sciences quelled these stories, some lingering doubts remained for many years.

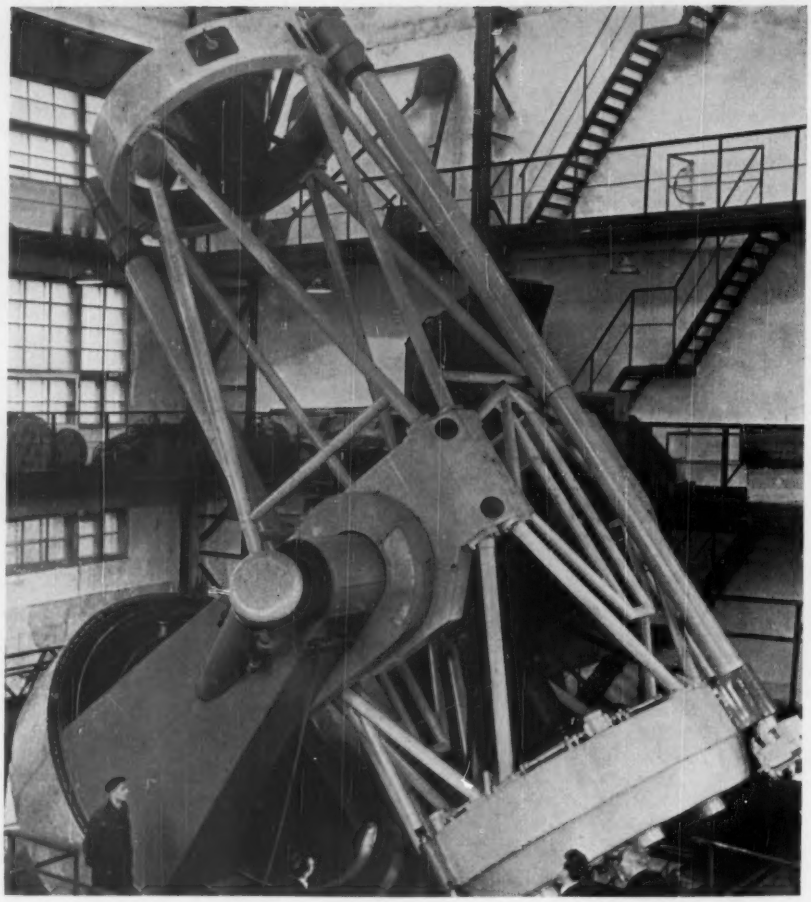
In 1835, C. L. Littrow, director of Vienna Observatory, discovered among its archives Hell's original journals, and published them in a book that attracted wide attention. Littrow took a highly critical view of Hell's veracity, and denounced the Vardo observations as proven forgeries. The evidence was clear, according to Littrow: The original ink figures for the contact times had been scraped out of the paper, and others inserted; in many places in the manuscript, changes had been made with ink of a slightly different color.

The reputation of Father Hell remained in eclipse for half a century, until the famous American astronomer Simon Newcomb happened to visit Vienna Observatory in 1883. Being especially interested in transits of Venus, he asked to be shown Hell's journal. Studying the manuscript with great care, he began to find curious discrepancies with Littrow's description of it. For one thing, many of the alleged alterations had been made before the ink had dried; the writer on making a mistake had rubbed it out with his finger.

To settle whether the original contact times had actually been erased, Newcomb examined the paper under a magnifying glass by grazing light. Nothing had been erased, but evidently ink had not flowed freely from Hell's pen, so he had written his figures over again for clarity.

There remained only Littrow's allegation that changes had been made with ink of a different color. To Newcomb, the manuscript had merely been retouched with the same kind of ink, which looked a little darker on drying. On inquiry, he found that Littrow's color vision was so defective that he could not distinguish the tint of Aldebaran from that of the whitest star. In Newcomb's words, "No further research was necessary. For half a century the astronomical world had based an impression on the innocent but mistaken evidence of a color-blind man respecting the tints of ink in a manuscript."

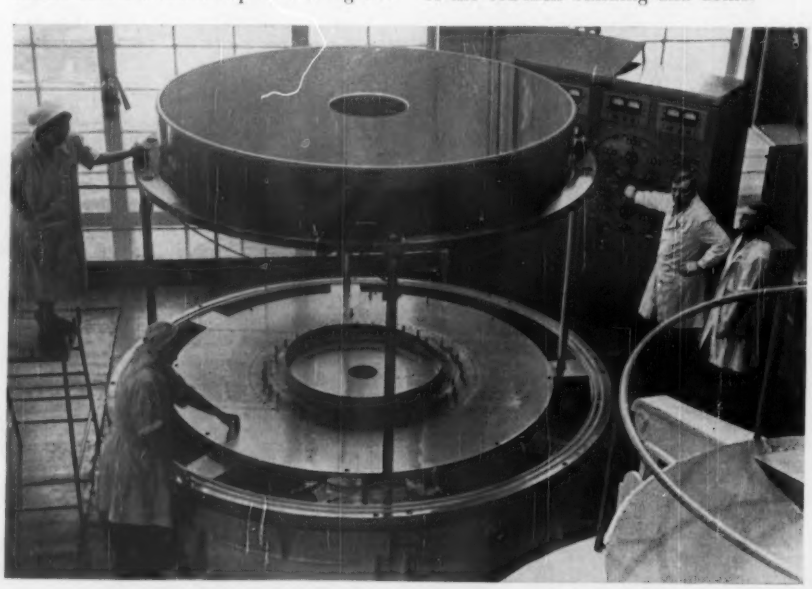
JOSEPH ASHBROOK



EUROPE'S LARGEST REFLECTOR IS BUILT IN SOVIET UNION

In these recent photographs from the U. S. S. R. are seen the new 102-inch telescope of the Crimean Astrophysical Observatory and its primary mirror. The fork-mounted 70-ton reflector was set up in the Optical and Mechanical Works at Leningrad. On the near end of the declination axis is a round cap containing one of the coude system mirrors. The tube structure resembles that of the 120-inch Lick Observatory reflector.

The view below is of the four-ton mirror and the base of its aluminizing tank. See page 82, February issue, for Patrick Moore's photographs, taken last October, of the 102-inch building and dome.



Amateur Astronomers

Notes on the Astronomical League Convention

PREPARING for the 15th general convention of the Astronomical League, June 30th to July 3rd, the Detroit Astronomical Society has set up a tentative program. It includes, in addition to the regular meeting sessions, addresses by Fred T. Haddock, Jr., of the University of Michigan and Helen Sawyer Hogg, David Dunlap Observatory, as well as meetings of the Association of Lunar and Planetary Observers and of the league's Great Lakes region.

A field trip to the Portage Lake facilities of the University of Michigan will be held on Saturday. This installation consists of two radio telescopes, of 28- and 85-foot diameters, a 24-inch Schmidt telescope, and a 24-inch reflector.

Persons to contact for specific information were listed in Sky and Telescope for February, page 96. For room reservations, write directly to the Henrose Hotel, Detroit 26, Mich., with a mention of the convention in order to secure the special rate.

We hope to have on exhibit the greatest number and variety of amateur telescopes ever collected. The hotel will store any exhibits sent in advance and guard the displays during the convention.

JOSEPH MAPLE
20116 California Ave.
St. Clair Shores, Mich.

WESTERN AMATEUR ASTRONOMERS TO MEET

Papers are now being accepted for this year's convention of the Western Amateur Astronomers in Long Beach, California, August 24-26. The meeting's theme is the "Amateur's Contribution to Astronomy." Sessions are to be held jointly with the Association of Lunar and Planetary Observers.

A highlight of the convention will be an award of the Blair medal to Carl Wells of Roseville, California, at the final banquet on Saturday, the 26th.

The Lafayette Hotel in Long Beach will serve as headquarters. Further information may be obtained from the WAA secretary, Mrs. Ruby L. Perkins, 4636 Vineta Ave., La Canada, Calif.

MID-STATES CONVENTION

The 11th annual convention of the Mid-States region of the Astronomical League will be held June 16-18, 1961, at the Morrison Observatory of Central College in Fayette, Missouri. Housing will be in the college dormitories, and all meals from Friday evening through Sunday noon will be served at the student cafeteria. Total cost for housing and food is to be $10.75, with a $1.00 registration fee for the meeting.

April 25th is the deadline for titles of papers to be presented. These and reservations should be submitted to general chairman Russell C. Maag, 211 S. Oak St., California, Mo.

NORTHWEST CONVENTION

On June 17-18 the North Central Washington Astronomical Society will be host to the annual get-together of the Northwest region of the Astronomical League. This year's meeting is to be at Wenatchee Valley College, and plans call for a star party, exhibits, and a picnic lunch.

Chairman of the convention committee is C. R. Goodman, 1230 Brown St., Wenatchee, Wash. Exhibits are being handled by Herbert A. Ikenberry, 1259

A Polish Amateur's Observatory

FOR 10 years I had dreamed of building my own observing station, but it was only when I moved from the center to the outskirts of Warsaw that this became possible.

The small observatory was built on the roof of my house, so the horizon is visible in all directions. The shelter is made from wooden planks and painted white; eight steel fastenings fix its floor to beams in the house roof. Since the structure is rather small, all observations are made from a sitting position. The observatory roof opens completely.

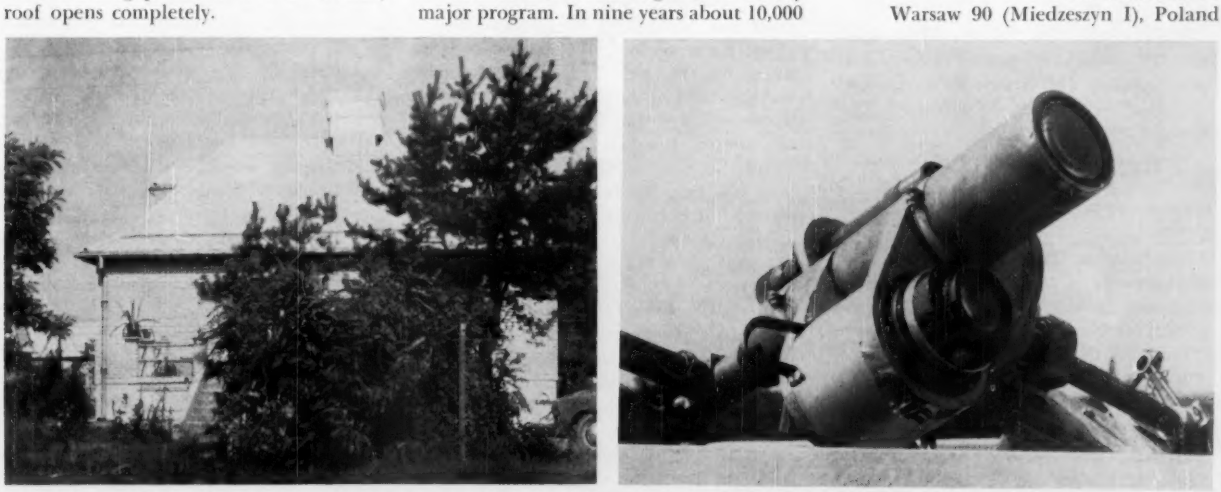
A 3-inch f/6.7 refractor is very stably mounted on the house's air shaft, which has foundations in the ground. The axes of the mounting, taken from an automobile, turn on ball bearings. Mounted alongside the telescope is a camera, its German war-surplus 2.5-inch objective having a focal ratio of 2.7.

I am now constructing an 8-inch f/4 reflector that will be put on the same mounting and is to have an electric clock drive.

Variable star observing has been my major program. In nine years about 10,000 brightness estimates have been made, using A. A. Nijland's method. Some of my work has been published in Polish scientific journals.

Having recently completed a simple visual photometer, I can measure the brightness of a star with an accuracy of ±0.03 magnitude in a few minutes. Encouraged by the results obtained so far, I plan to build a photoelectric photometer. I am a member of the Polish Astronomical Society and the Polish Amateur Astronomical Society.

ANDRZEJ T. MARKS
Ul. Szafirowa 16
Warsaw 90 (Miedzeszyn I), Poland



On the outskirts of Warsaw, Poland, Andrzej T. Marks built a compact rooftop observatory. In the left-hand picture, the house is seen from the south, and the observatory is the small white shelter perched on top. The roof of the latter is closed. On the right is a close-up view of the refractor and camera, which extend above the sides of the shelter when they are in use. Mr. Marks specializes in observing variable stars.

S.E. 1st St., E. Wenatchee. Papers, which should be limited to 15 minutes, are now being accepted by Mrs. Jane Belt, 827 Cascade St., Wenatchee.

NORTHEAST CONVENTION

Rochester, New York, is the location for the 1961 convention of the Astronomical League's Northeast region, May 26-28. Sessions for business and papers will be held in the Manger Hotel, while sightseeing tours are planned to Kodak Park, the Rochester Museum of Arts and Sciences, and Bausch and Lomb (to see pouring of optical glass).

The chairman of the Rochester Academy of Science's convention committee is Ralph K. Dakin, 720 Pittsford-Victor Rd., Pittsford, N. Y.

THIS MONTH'S PROGRAMS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. April 14, Dr. Marshal H. Wrubel, Indiana University, "The Roles of Hydrogen in the Universe."

Marietta, Ohio: Marietta Astronomical Society, 7:30 p.m., Cisler Terrace. April 29, symposium, "The Expanding Universe."

New Orleans, La.: Pontchartrain Astronomy Society, 8 p.m., Tulane University Navy building. April 7, Lt. Comdr. B. B. Crawford, Tulane University, "Celestial Navigation, Past, Present, and Future."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. April 5, Dr. Lyle B. Borst, New York University, "A Tale of Two Atmospheres — Earth's and Moon's."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly Building, New York University. April 21, Dr. Carl C. Kiess, Georgetown College Observatory, "Recent Spectroscopic Studies of the Planets and a New Explanation of Martian Phenomena."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. April 5, Dr. Cecilia Payne-Gaposchkin, Harvard College Observatory, "Life Span of the Stars."

Syracuse, N. Y.: Syracuse Astronomical Society, 8 p.m., Steele Hall, Syracuse University. April 27, Robert Havlen, "The Moon."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. April 1, Raymond J. Seeger, National Science Foundation, "World Without End."

LINCOLN, NEBRASKA

Thirty amateur astronomers in Lincoln, Nebraska, have formed the Prairie Sky Club, which meets the first Friday of every month in the Nebraska Wesleyan University science building. Those interested should contact J. L. Williams, 1315 S. 40th St., Lincoln, Neb.

+++ AMATEUR BRIEFS +++

The Aldrich Astronomical Society, Worcester, Massachusetts, suggests a cloudy-night project for slide enthusiasts. Insert squares of black construction paper in 35-mm. slide holders, and prick out the constellations with a thin needle. Relative stellar magnitudes may be depicted by using different needles; colors can be shown by cementing appropriately tinted cellophane patches over the holes.

A one-year program of astronomical research has been mapped out by members of the Key Biscayne Astronomical Association, which has branches in Florida and Illinois. Six major constellations are to be studied for two months each, in any way individual club members select.

On the reverse side of the Denver Astronomical Society's general information sheet is printed the 1956 Mars map of the Association of Lunar and Planetary Observers.

The second annual class in celestial navigation is now being given at the Morrison Planetarium, Golden Gate Park, San Francisco, California. Under the guidance of Comdr. M. R. Amsden, U.S.N.R., the instruction includes both theory and practice in course plotting.

In 1836, notes the bulletin of the Thames Amateur Astronomical Society, New London, Connecticut, the largest refractor in the United States was the 6-inch telescope at Wesleyan University in Middletown, Connecticut!

The 1961 calendar published by the Sydney, Australia, Amateur Astronomers contains, in addition to monthly listings of celestial phenomena for Southern Hemisphere observers, tentative society programs and astronomy class schedules. It may be hung on a wall for easy reference.

The mirror making class of the Mt. Diablo Astronomical Society in Walnut Creek, California, has discovered that a good way to even off mirror blanks is to grind them against a flat piece of steel, using No. 80 grit. This takes about 30 minutes, saving much time usually spent in obtaining contact between the tool and an uneven blank. Class members also grind the backs of their blanks with 120 and 220 grit, finishing with 400, so the mirrors sit evenly in their cells.

G. B. C.

TAPE RECORDERS IN THE DARKROOM

A note concerning tape recorders on page 95 of the February issue mentioned their use by amateur astronomers. I have been employing tape recordings to obtain better development of astronomical color photographs. With their aid I have processed beautiful color slides of lunar craters and maria in an early twilight sky, and have recorded the colors of bright stars, clusters, and nebulae.

Darkroom procedures for color film must be very accurately timed, and constant agitation is necessary during processing of such films as Ektachrome and Anscochrome. I do not handle color film frequently enough to keep entirely familiar with the routine. But this is no problem if the instructions and development countdown are played out loud from a magnetic tape.

Ultra-thin Mylar-base tape is used in order to obtain sufficient time to complete the process on one reel. The countdown is read onto the tape from an accurate clock with a sweep second hand, and the film manufacturer's directions are combined with such added information as my experience has shown to be useful.

WILLIAM C. DAVIS
206-B S. 14th St.
St. Joseph, Mo.

ASTRONOMICAL MNEMONICS

One way to remember the names of the principal planets in order from Mercury to Pluto is by the initial letters of the sentence: "Many volcanoes erupt moldy jam sandwiches usually not palatable." Likewise, the phrase "Certain planets journey very ancient heavens in faint magnitudes" can help recall that the first nine asteroids are Ceres, Pallas, Juno, Vesta, Astraea, Hebe, Iris, Flora, and Metis. Readers are invited to submit similar devices for recollecting astronomical names or facts.

AMATEURS OBSERVE LUNAR ECLIPSE IN MARCH

Excellent results were reported for the March 2nd partial eclipse of the moon (page 182 of last month's issue). E. M. Brewer, of the Texas Astronomical Society in Dallas, noted that at 6:50 a.m. Central standard time (eight minutes before moonset), 85 per cent of the lunar disk appeared copper, this color extending up to the bright crescent.

Two California amateurs described their observations. At Orange, Thomas C. Porter timed the entrance of 14 craters into the umbra, using a 3-inch reflector at 62x. He had very good seeing until 13:00 Universal time (about half an hour before mid-eclipse), when light clouds appeared and prevented further observations. William J. Westbrooke of San Francisco used a 1¼-inch refractor to time the covering of Aristarchus, Copernicus, and Tycho. Seeing was only fair, with intermittent clouds.

In Honolulu, Hawaii, Louis Miller photographed the event, securing 21 pictures. His telescope was a 3-inch f/8 refractor, and exposures were 1/25 second on Kodak Plus-X film. An effective focal length near 88 inches was obtained by using a camera lens about 10½ inches from the film, giving a lunar image 0.8 inch in diameter. His exposures began at 10:45 UT and ended at 14:03, 35 minutes after mid-eclipse at 13:28.

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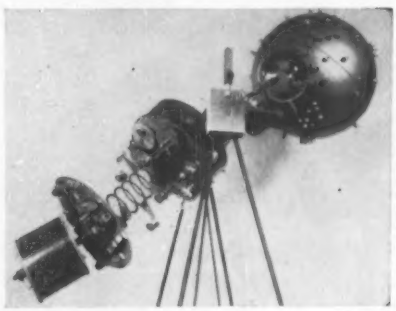

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OBSERVER'S PAGE

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Observations of RZ Cassiopeiae

THE eclipsing variable star RZ Cassiopeiae is noteworthy for its unpredictable changes in period. Hence it is very desirable that times of minimum be observed at frequent intervals. The considerable range in magnitude and the rapidity of light change make it easy for amateurs to time the minima visually — or even better, photoelectrically. A finding chart and ephemeris of RZ Cassiopeiae were published on page 310 of SKY AND TELESCOPE for November, 1960, with a request for amateur observations.

A total of 16 minima have been collected. Five of these are from photoelectric measurements by D. Engelkemeir, Hinsdale, Illinois, and J. Ruiz, Dannemora, New York. Both used photometers containing 1P21 photomultiplier tubes, on 8- and 12-inch reflectors, respectively.

Visual series were made by B. Gardner, Fullerton, Pennsylvania; R. N. Watts, Jr., Winchester, Massachusetts; J. Ashbrook, Weston, Massachusetts; and H. Ayala, Cuidad Juarez, Chihuahua, Mexico. The instruments used ranged from 8 x 30 binoculars to a 2-inch refractor. H. E. M. Specht, of New Haven, Connecticut, observed one minimum photographically, taking multiple-exposure plates with a camera of 30-inch focus.

The deduced times of minima are tabulated here in the form of Julian dates, the first two digits (24) being omitted throughout. All the times are heliocentric. They are compared with the following prediction formula, given in the 1958 Moscow *General Catalogue of Variable Stars:*

$$\text{J.D. Min.} = 2417355.4233 + 1^d.1952519E$$

where E is the whole number of cycles elapsed since the initial epoch. This expression describes the average behavior of RZ Cassiopeiae since its variability was discovered in 1906. In the table, $O - C$ is the observed minus the predicted time of midminimum, and n is the number of observations during that eclipse.

Mr. Engelkemeir's two photoelectric minima in 1959 indicate that the eclipses were occurring 0.0202 day earlier than predicted in October of that year. The later photoelectric results show that this difference had grown to 0.0265 day by November, 1960. The average of the 11 visual and photographic minima gives precisely the same residual, 0.0265 day, for October, 1960, with a mean error of ±0.0012 day.

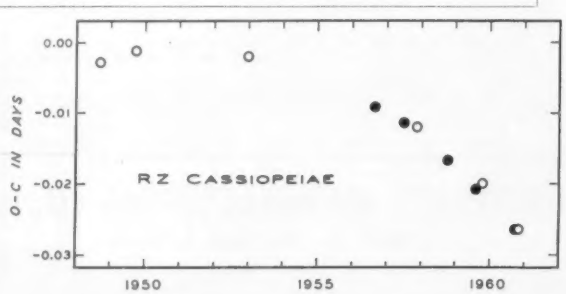
The internal accuracy of the photoelectric timings is obviously much better than in the visual work, which is, nevertheless, adequate to show the general course of the period's variation.

Further observations of RZ Cassiopeiae next fall and winter are desired, to see whether or not the minima will be coming even farther ahead of schedule.

J. A.

OBSERVED TIMES OF MINIMA OF RZ CASSIOPEIAE

J.D. Min.	*E*	*O − C*	*n*	*Observer*
		Photoelectric Observations		
36823.6663	+16,288	−0^d.0199	22	Engelkemeir (1959)
36884.6236	+16,339	−0.0205	25	Engelkemeir (1959)
37227.6551	+16,626	−0.0263	14	Engelkemeir
37246.7786	+16,642	−0.0268	27	Ruiz
37263.5126	+16,656	−0.0263	—	Ruiz
		Visual Observations		
37141.590	+16,554	−0.033	12	Ashbrook
37147.569	+16,559	−0.031	6	Ashbrook
37171.477	+16,579	−0.028	7	Ashbrook
37172.670	+16,580	−0.030	21	Ashbrook
37196.582	+16,600	−0.023	10	Ashbrook
37220.485	+16,620	−0.025	13	Ashbrook
37220.486	+16,620	−0.024	8	Watts
37294.586	+16,682	−0.029	10	Specht (photographic)
37306.546	+16,692	−0.022	9	Gardner
37319.689	+16,703	−0.027	6	Ayala
37331.649	+16,713	−0.019	8	Ayala



The difference between observed and computed times of minima for RZ Cassiopeiae is increasing, as shown here. Circles are photoelectric means, dots are visual. Data before 1960 are primarily from "Eclipsing Binaries Circular" of Krakow Observatory.

MESSIER OBJECTS FOR SPRING VIEWING

THE newly formed Messier club at the Royal Astronomical Society of Canada's Ottawa Centre has compiled a convenient observing list from Owen Gingerich's table of Messier objects in SKY AND TELESCOPE for March, 1954, page 158. Our list contains four parts, corresponding to the seasons of the year, and each part is subdivided by constellations from north to south in the sky. Within each constellation the catalogue objects are listed roughly from west to east.

The symbols for type of object are: E, elliptical galaxies; G, globular clusters; I, irregular galaxies; P, planetary nebulae; and S, spiral galaxies. The co-ordinates are for epoch 1950, and the magnitudes are approximate visual values.

M	*Type*	*R. A.* h m	*Dec.* ° ′	*Mag.*	*Size* ′
URSA MAJOR					
81	S	9 52	+69 18	8	16 × 10
82	I	9 52	+69 56	9	7 × 2
97	P	11 12	+55 18	11	3 × 3
108	S	11 09	+55 57	10	8 × 2
109	S	11 55	+53 39	11	7
101	S	14 01	+54 35	8	22 × 22
CANES VENATICI					
106	S	12 16	+47 35	10	20 × 6
94	S	12 49	+41 23	8	5 × 4
63	S	13 14	+42 17	10	8 × 3
51	S	13 28	+47 27	9	12 × 6
3	G	13 40	+28 38	6	19
LEO					
95	S	10 41	+11 58	11	3 × 3
96	S	10 44	+12 05	10	7 × 4
105	E	10 45	+12 51	10	2 × 2
65	S	11 16	+13 23	10	8 × 2
66	S	11 18	+13 17	9	8 × 2
COMA BERENICES					
64	S	12 54	+21 57	8	8 × 4
53	G	13 10	+18 26	8	14
VIRGO					
49	E	12 27	+8 16	9	4 × 4
61	S	12 19	+4 45	10	6 × 6
104	S	12 37	−11 21	8	7 × 2
COMA-VIRGO GROUP					
98	S	12 11	+15 11	11	8 × 2
99	S	12 16	+14 42	10	4 × 4
100	S	12 20	+16 06	10	5 × 5
85	E	12 23	+18 28	10	4 × 2
84	E	12 23	+13 10	10	3 × 3
86	E	12 24	+13 13	10	4 × 3
88	S	12 30	+14 42	10	6 × 3
87	E	12 28	+12 40	10	3 × 3
89	E	12 33	+12 50	11	2 × 2
90	S	12 34	+13 26	11	6 × 3
58	S	12 35	+12 05	10	4 × 3
59	E	12 40	+11 55	11	3 × 2
60	E	12 41	+11 49	10	4 × 3
HYDRA					
68	G	12 37	−26 29	8	9
83	S	13 34	−29 37	9	10 × 8

Galaxies predominate in the spring list given here, because we are looking mostly toward the galactic pole regions, away from the obscuring clouds of the Milky Way. Worthy of note are the Whirlpool (M51), Black-eye (M64), and Sombrero (M104) nebulae, which are spiral galaxies, and the Owl nebula (M97), a planetary. The Coma-Virgo group of galaxies includes the most distant Messier objects, about 20 million light-years away.

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SUNSPOT NUMBERS

The following American sunspot numbers for January have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

January 1, 116; **2,** 109; **3,** 108; **4,** 82; **5,** 69; **6,** 57; **7,** 55; **8,** 45; **9,** 39; **10,** 32; **11,** 33; **12,** 19; **13,** 14; **14,** 17; **15,** 24; **16,** 30; **17,** 44; **18,** 44; **19,** 44; **20,** 38; **21,** 38; **22,** 34; **23,** 19; **24,** 15; **25,** 22; **26,** 26; **27,** 36; **28,** 63; **29,** 58; **30,** 52; **31,** 53. Mean for January, 46.3.

Below are provisional mean relative sunspot numbers for February by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

February 1, 55; **2,** 57; **3,** 59; **4,** 75; **5,** 61; **6,** 56; **7,** 52; **8,** 55; **9,** 68; **10,** 61; **11,** 41; **12,** 28; **13,** 26; **14,** 26; **15,** 27; **16,** 17; **17,** 38; **18,** 30; **19,** 20; **20,** 22; **21,** 42; **22,** 46; **23,** 41; **24,** 56; **25,** 50; **26,** 49; **27,** 42; **28,** 17. Mean for February, 43.5.

Dr. Waldmeier has provided the following predictions of smoothed monthly sunspot numbers for the coming months: April, 69; May, 66; June, 63; July, 60.

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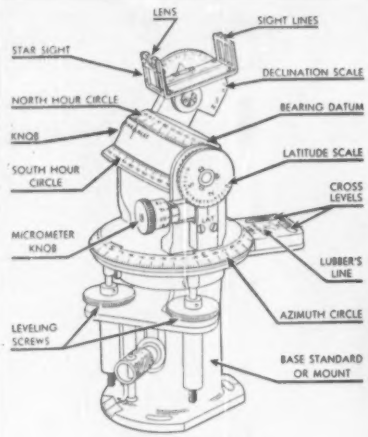

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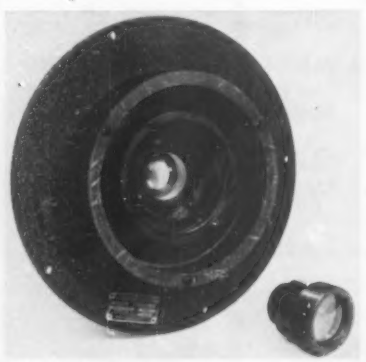

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(Left in photo) B & L, 6" focal length, f/6.3, 93° wide-angle aerial camera lens in Fairchild lens cone. Built-in haze filter and diaphragm. Lens will cover up to 8 x 10 film. Original cost $1,000.00. With case, only $39.50 postpaid.

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All items accurately described.

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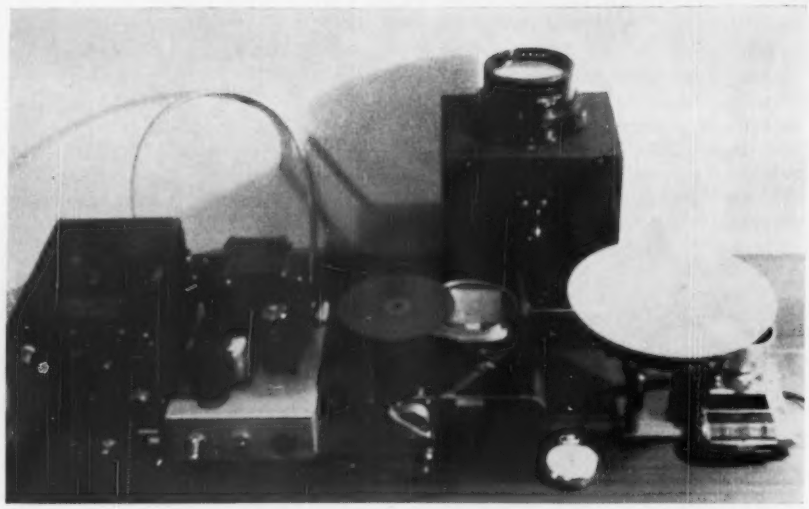


The equipment used by Walter A. Feibelman for photographing meteor spectra.

A Perseid Meteor Spectrum

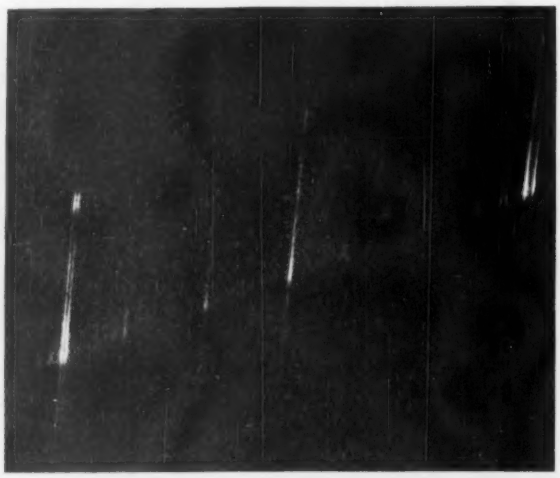
PHOTOGRAPHY of meteor spectra is a rewarding amateur project, requiring great patience but only simple equipment. An f/3 or faster camera with a prism or diffraction grating in front of its lens can record the spectrum of a meteor of magnitude 0 or brighter, provided the observer is willing to sacrifice about 50 rolls of film.

Instructions for this kind of work are given by P. M. Millman in *Amateur Telescope Making — Book II,* page 544. The amateur should also consult Sky and Telescope articles by Dr. Millman in August, 1956, page 445, and by John A. Russell on page 549 of August, 1959.

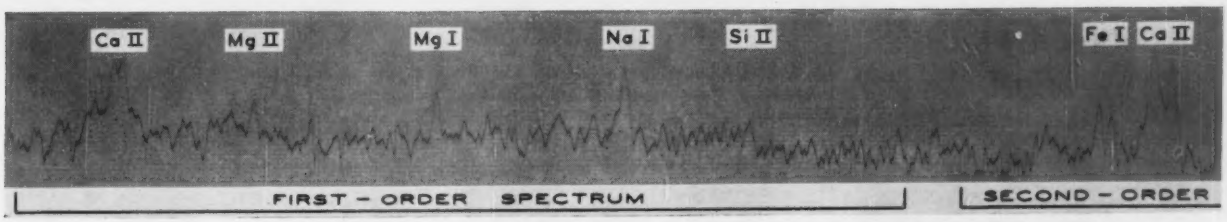
It is best to concentrate effort on nights when rich showers are expected, as the chance of catching a bright sporadic meteor at the right time in the right place with the right direction of motion is very small. After five years, I succeeded in recording the spectrum of a Perseid meteor on the morning of August 10, 1958. This meteor was estimated to be magnitude −1 or brighter. It appeared in Draco at 7:47:02 Universal time, and left a train visible for four seconds.

Pictured here is some of the equipment used. The spectrum was secured with the small folding camera in the center, which has a Trioplan lens of 75-mm. focus, used at f/2.9 with Kodak Royal-X Pan film. Covering the lens is a Bausch and Lomb precision replica transmission grating, having 300 lines per millimeter. The combination gives a spectrum about six millimeters long, with a dispersion of 440 angstroms per millimeter in the first order.

Mine is a blazed grating, its grooves cut in such a shape that most of the light is concentrated in the first order of the spectrum, whereas an unblazed grating spreads light into many orders and gives weak images. The important advantage of blazed gratings was demonstrated when the Perseid spectrogram was secured. Simultaneously I made a second exposure with a faster camera (on the right in the picture), whose f/2 lens was equipped with an unblazed replica. It recorded not a trace of the spectrum.



The spectrum of a Perseid shower meteor, photographed by the author on August 10, 1958. The meteor's motion was downward on the page. The first-order spectrum is shown completely, with the pair of H and K ionized calcium lines at the left. They are seen again in the second order, at upper right. As it penetrated the atmosphere, the meteor flared irregularly, causing the brightness changes along each line. P. M. Millman has identified 23 spectral lines on the original negative.



This microphotometer tracing of the Perseid meteor spectrum shows lines identified by Mr. Feibelman. Because of the graininess of the film, some of the fluctuations in the trace may be photographic effects rather than spectral features. Red is toward the right. All photographs with this article are courtesy of the author.

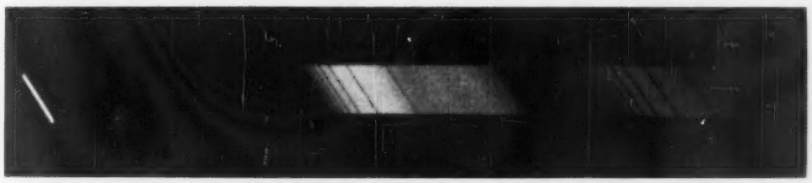
Another part of my equipment, not used for this spectrum, is a rotating shutter that occults the lens 60 times a second. It breaks the trail into segments, from whose lengths the angular velocity of the meteor can be calculated if the speed of the motor is accurately known.

I have found that on moonless nights film can be exposed for 15 minutes before serious fogging takes place. This film had been exposed only two minutes when the meteor appeared, and the shutter was closed immediately. Thus the negative is fairly light, and the background star trails are short. The film was developed in DK-60a for eight minutes at 68° Fahrenheit, and is rather grainy.

Halftone reproduction of the spectrogram cannot retain all the detail in the original negative, where at least 11 lines appear in the first-order spectrum. Of these I have definitely identified six as due to ionized calcium, magnesium, and silicon, and neutral magnesium and sodium. It is easier to recognize the lines on a microphotometer tracing of the spectrum, as seen here in one of several tracings made with the assistance of K. B. Adams, formerly of Westinghouse Research Laboratories.

Ideally, the direction of dispersion of the grating should be at right angles to the motion of the meteor across the field. For the present picture the angle was 66 degrees. Once, about four years ago, I photographed a very bright sporadic meteor. Unfortunately, it was traveling parallel to the dispersion, and yielded a strong zero-order image but no spectrum, as all the orders fell on the trail of the meteor itself!

WALTER A. FEIBELMAN
1063 Findley Dr.
Pittsburgh 21, Pa.



This spectrum of Vega, for equipment calibration, shows the zero, first, and second orders. The star was allowed to trail in order to give height to the spectrum. Note the greater intensity of the first order due to the blazing of the grating. The dark lines are the Balmer series of hydrogen.

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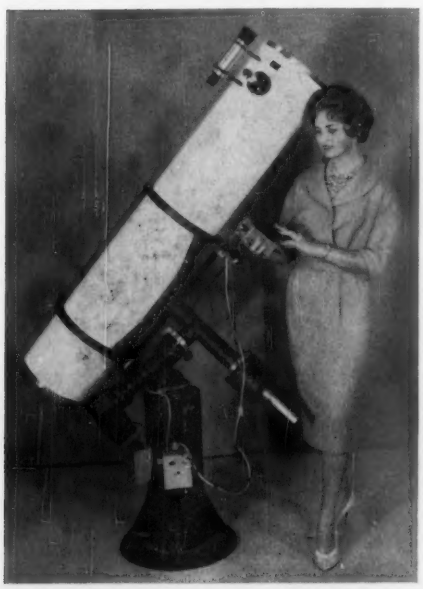

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BRIGHT METEOR SEEN OVER CALIFORNIA

A spectacular fireball over California caught the attention of thousands of people on the evening of January 16, 1961. Radio newscasts all over the country mentioned it.

In Ojai, Jim Wright and other students at the Thacher School were on their way to a 6 p.m. class when they noticed a blue flash. Turning around, they saw a bluish-white fireball moving slowly across the sky and beginning to redden. Finally it split in two, becoming very red. The object was brighter than Venus, according to their report, which gives the time as 5:57 p.m. Pacific standard time.

At Seal Beach, Robert L. Chew spotted the fireball when it was about 60 degrees above the horizon and traveling in a northwesterly direction toward the Pacific. For him the meteor was an intense orange color leaving a greenish-white trail. Requiring 10 seconds to cross the sky, it fell to within about five degrees of the horizon, where it "fizzled out with a furious burst of sparks."

OCCULTATION OF ALDEBARAN

On December 29-30, 1960, seven members of the Van Nuys Astronomical Society timed the occultation of Aldebaran by the moon. Two methods were used. In one, a stop watch was started from WWV 5-megacycle signals at 7:25:00 Universal time, and then stopped when the star disappeared.

The other technique was to record the time signals continually on tape, pressing a buzzer to indicate the moment of immersion. The stop watch gave a time of 7:27:14.3 UT, the buzzer system 7:27:14.1.

Seeing conditions were very good, with transparency about as high as possible in this area. The observations were made from my home, latitude +34° 11′, longitude +118° 26′, and elevation about 900 feet above sea level.

RONALD S. CHALDU

14312 Cohasset St.

Van Nuys, Calif.

JUPITER-SATURN CONJUNCTION

On the morning of February 18th, brilliant Jupiter slowly passed one-fifth of a degree south of Saturn. Although their actual conjunction occurred in daylight — at 10 a.m. Eastern standard time, 7 a.m. Pacific — the planets formed a beautiful close pair in the dawn sky.

Many amateurs in the western part of the country photographed the two planets in the morning twilight. At Henderson, Texas, Kenneth A. Wayland and Curtis Jones took the picture below at 6:30 a.m. Central standard time.

At Las Cruces, New Mexico, Gordon Solberg set two alarm clocks for 4:45 a.m. to be sure he'd waken in time. The sky was so clear that at first he mistook the brilliant Milky Way for a bank of cloud in the east. As Jupiter and Saturn rose, they could be seen together in the field of a 150-power eyepiece. At 6 o'clock he called KGRT, a local radio station, which broadcast information for others in the town to observe the conjunction.

In California, Eugene A. Harlan, Los Gatos, photographed the pair of planets at 6 a.m. Roderick R. Dunphy at Monta Vista used a 2½-inch refractor and a 35-mm. camera to record the event.

Jupiter and Saturn in the morning sky, photographed by Kenneth A. Wayland and Curtis Jones at Henderson, Texas, 10 minutes before sunrise on February 18th. The brighter of the two planets is Jupiter, at this time slightly to the west of Saturn, as the conjunction was still 2½ hours off. Exposure was four seconds at f/5.6 on Kodak Tri-X film, which was developed normally in DK-50.

QUESTAR NEWS • *April-May, 1961*

In 1955 a Questar was purchased by the world-famous Dr. C. E. K. Mees, Director of the Eastman Kodak Research Laboratories. What especially pleased us at the time was his remark to a colleague that "he had bought it because it had the finest diffraction image he had ever seen outside of textbooks."

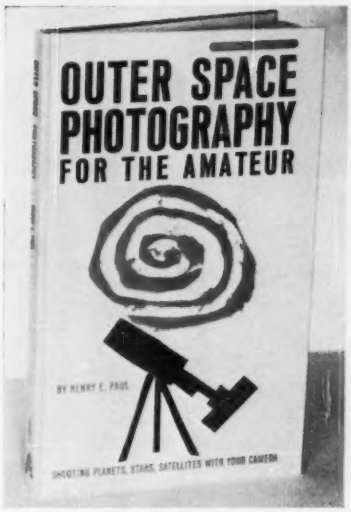
As you probably know, we decided a long time ago to protect the privacy of each Questar owner. We do not disclose their names and addresses, never send prospects to their door, or ask them to act as demonstrators for our product. Many Questar owners have especially asked us to send prospects to them, and have sometimes been annoyed by our refusal to do so, for we still think it is the only nice way of dealing with our clients over the breadth of years to come.

There have been times when we wished we could tell the world that Dr. Mees was enjoying his Questar and used it often at his home in Hawaii, to which he had retired. With his passing last summer, we can now speak freely and mention that in his will he bequeathed his Questar to the University of Hawaii.

Perhaps we have been too strict about mentioning famous people who own Questars. Most of them have adequate privacy shields as a matter of course. So we might mention that the Cary Grants own two Questars. Mr. Grant explained that they have three houses — his wife has one, he has one, and they have one, so that is why he bought the second Questar. We hope this is clear — three houses, two Questars.

Questar's offices and plant are located in open country three miles from New Hope, Pennsylvania. This is 65 miles southwest of New York and 40 miles due north of Philadelphia. We had to find another secretary by February 1st this year, and found ourselves envying city folks, because good capable secretaries who can run IBM executive typewriters do not seem to grow on our local trees out here in the sticks. After two weeks of interviews, we found Miss Janet Gemmill splendidly qualified, praise Allah, and living in a nearby town. As we tried to explain her duties in the telescope business, we mentioned that long-distance calls were frequent and occasionally we had distinguished visitors. At once we realized our error — the likelihood, of course, was that all calls for the first week would be local ones and the only visitor the trash man. But on her first day every call we had was transcontinental, and who should walk in to take delivery of a Questar but Dr. L. E. Flory from Princeton and the great Dr. V. K. Zworykin, who perfected television. And why were these distinguished gentlemen choosing a Questar that day? Dr. Z. said that, having completed the fantastically accurate automatic control and guiding system for the Stratoscope II 36-inch balloon-borne quartz telescope project, they were now about to tackle the control system for a larger manned telescope in a space vehicle which will operate from orbit. For convenience the system will point the little Questar instead of the huge machine it will eventually control. What a wonderful business this is when it gives us such glimpses of the instrumental frontier!

But our business has other days too. We are coming to think of the daily struggle for quality control as the Battle That Is Never Won. We find that we have 102 suppliers, and constantly riding herd on so many separate sources turns out to be no small task.



We urge you to get this splendid book because there is nothing like it! Send $2.50 to AMPHOTO, 33 W. 60th St., New York 23, N. Y.

Inspection, of course, is the answer. But it can be mighty inconvenient when about 4,000 parts arrive from three separate sources the same afternoon. This means that somebody has to stop making Questars and become inspector. We have to check every piece or spot-check every shipment as soon as it arrives, to make sure it is right before we accept it and put it into inventory.

About once a week some supplier goofs on something he has been making perfectly for years. Sometimes several things go wrong at once. These are the days we are apt to wonder what keeps the whole economy glued together. What brings on this lament? The fact that yesterday our production manager had to spend his entire day at the plant of a distant supplier getting his boys back on the rails again.

We are pleased to tell you that on January 17 the Hayden Planetarium, of the Museum of Natural History in New York, took delivery of a Questar which will be used for evening classes in astronomy.

It has always seemed to us that Questar was an ideal kind of instrument for any school. It can be stored in its case on the microscope shelf, there is no upkeep for dome or shelter, while it has no equal as a convenient clock-driven demonstration instrument. It is good to report that more and more schools are finding this out. The public schools of San Diego recently purchased three more Questars, Yuba City High in California bought one, and Southern Connecticut State College in New Haven is taking another four.

In addition to several sales to individuals in Italy last year the Osservatorio Astronomico di Capodimonte recently bought a quartz-mirrored Questar outfit with large solar filter and camera. The Royal Institute of Technology in Stockholm purchased another, and the Dominion Observatory in Canada has just taken delivery of two quartz Questars.

In scanning our client registration book we find so many institutions have become Questar users that it would bore you to hear much more about them. We do note that several went to Atomic Energy Commission installations, and several were purchased by the National Aeronautics and Space Administration.

The Naval Air Development Center at Johnsville, Pennsylvania, is not far from us, and they have had a Questar for some time. Remarkable strides have been made there in miniaturizing aerial photographic equipment with an actual gain in efficiency. The standard size film is no longer 9 inches wide but is now the 70-mm. kind, as used in wide-screen movies. We see and hear aircraft from their field both day and night, taking pictures under all conditions.

Recently the team of astronauts being readied for space travel has been training there. Captain Benson, a Navy doctor working on space problems, set up their Questar and was pleased to find he secured fine photographs in both black-and-white and color of the November 7 transit of Mercury. We spent a fascinating afternoon with Captain Benson at Johnsville testing Questar in the circular centrifuge building that houses the gigantic rotating arm which simulates the effects of gravity on accelerating objects. As you may know, Questar pioneered the thin-edged mirror disk supported wholly at the thicker circumference of a central hole. For space vehicle installations the question of this construction's sturdiness had come up. We can now tell anybody interested that any Questar will stand 36 g's axially in either direction without damage. And that is all the g's the centrifuges put out.

Did you know Navy pilots have for many months been wearing a workable space suit? We were assured this was so, and were shown a lightweight rig with helmet stretched on a long table. To demonstrate the suit's normal attitude under pressure a pump was started, causing the empty helmeted figure to move in eery fashion as it inflated. Once more we experienced a sense of disbelief: We have heard of the vacuum-proof suit for 30 years, and it now is here.

From the Army installation at Fort Monmouth came most gratifying news in January. An engineer called us and said that the staff of lens and photographic specialists there had been amazed at the performance of a Questar just delivered to them. It was, said he, consistently resolving 1 second of arc easily instead of the 1.4-second Rayleigh or 1.3-second Dawes rating for its 3.5-inch aperture. It was beating the resolution obtained from four catadioptric photographic lenses of from 40 to 150 inches focal length, all of larger aperture. Further, he said, their optical system expert had never seen so fine a diffraction image.

We made a date and in a few days a delegation arrived to ask us how we did it. All we could tell them is that it is a question of policy. We think our business future depends on quality, and the pursuit of quality is perhaps half a matter of determination and the other half a matter of conscience. Yes, it hurts to discard the almost-perfect set of optics, or the piece of metal that is just a little off. It is costly and often worrisome. But it is the only way a Questar can be made.

Lawrence Braymer, President

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Three galaxies in Leo: M65 (top right), M66 (lower right), and NGC 3628. West is at the top, north at the left in this photograph by C. P. Custer.

DEEP-SKY WONDERS

STARS are not the only celestial objects that can be observed as double, for owners of even small telescopes can find many pairs of galaxies. Most of these are presumably line-of-sight doubles rather than true binaries, and some are really single objects with two centers of brightness, such as NGC 2903, which was discussed in this column last month.

In the constellation Leo, well placed for April viewing, are a number of twin galaxies that make good tests for small instruments. (In each case, the brighter component is mentioned first, and its 1950 co-ordinates are given.) Perhaps best known is the pair of conspicuously elongated spirals, M66 and M65, at right ascension $11^h\ 17^m.6$, declination $+13°\ 17'$. Also known as NGC 3627 and 3623, respectively, they are 20′ apart on the sky. Admiral Smyth speaks of a third nebula closely following, but this is a mistake copied from John Herschel. However, there is another spiral a degree west of the Messier pair, numbered 3593 in the NGC and labeled 29^1 in Norton's *Star Atlas*. All three of these galaxies are easily seen with a 3-inch telescope.

A wider and fainter pair is M96 and M95 (NGC 3368 and 3351) at $10^h\ 44^m.2$, $+12°\ 05'$, which can be found in modest instruments. Nearby, look for NGC 3379 (M105) and 3384, at $10^h\ 45^m.2$, $+12°\ 51'$. The first is of the 9th magnitude, the second 10th, with diameters of only 2′ and 3′, respectively, and their separation is 7′. Both are elliptical galaxies. Clustered with them is a difficult 12th-magnitude spiral, NGC 3389, 2′ by 1′ in size. It lies about 6′ south and east of 3384. All three objects are plotted in the Skalnate Pleso atlas.

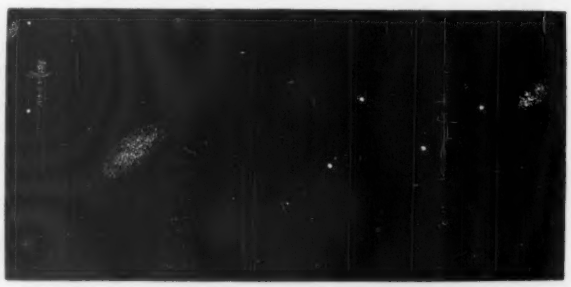
The 10th-magnitude elliptical galaxy NGC 3607, at $11^h\ 14^m.3$, $+18°\ 20'$, has a somewhat fainter companion about 6′ north, NGC 3608. Both are shown in the Skalnate Pleso atlas, which omits a third object, NGC 3599, at $11^h\ 12^m.8$, $+18°\ 23'$. Curiously, Norton's shows 3599 and 3607 only, with the designations 49^2 and 50^2.

Finally, in Coma Berenices, there is an interesting double, consisting of a globular cluster and a nebula. The globular is NGC 4147, at $12^h\ 07^m.6$, $+18°\ 49'$; it is 9th magnitude and only 2′ in diameter. About 15′ southeast of it is the galaxy NGC 4153, described in the *New General Catalogue* as "bright, pretty large, extended, and brighter in the middle." This object is plotted as 11^1 in Norton's atlas. Careful descriptions of its appearance in different-size telescopes will be particularly welcome. Readers should send them to me on post cards.

WALTER SCOTT HOUSTON

36 Lawn Ave.

Middletown, Conn.



Admiral Smyth recorded the appearance of M66 (right) and M65 through his telescope in this drawing from his book "A Cycle of Celestial Objects." He describes M66 as "a large elongated nebula, with a bright nucleus, on the Lion's haunch."

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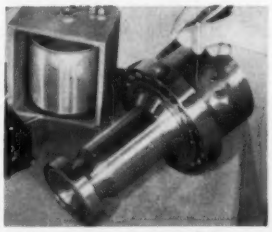

for its size. It moves smoothly, as rapidly or slowly as you want it to, with perfect freedom and balance. The reason: heavy-duty ball bearings on both axes. They're big, heavy-duty angular contact bearings of a kind not found in lesser telescopes.

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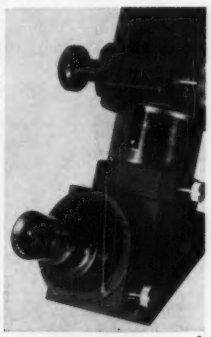
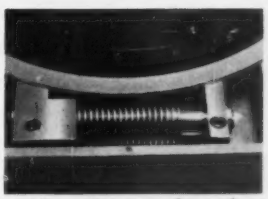
(3) The focusing assembly will please even the most exacting astronomers – it combines all the best features and engineering principles. For example: rack-and-pinion assembly (superior, by far, to slow-moving spiral assemblies); positive locking clamp for accuracy. The entire assembly can be removed, and replaced with a camera or spectrograph without loss of alignment. The assembly barrel –as you can see– is ruggedly built. Its 3-inch diameter makes it capable of handling



larger-than-average eyepieces and accessories.

(4) In the optical system, Tinsley's skill and experience comes into full play. Tinsley has been making professional telescopes for 30 years, and supplies optics for missiles and rockets. The Cassegrain system of the 12-inch has a primary focal length of 48″, secondary amplification of 4 and total effective focal length of 192″. The telescope is equipped with a finder of 10 power.

(5) In the motor drive and tracking system there are two Bodine motors in right ascension, one



for a precise sidereal rate; the other for fast drive at 5 times the sidereal rate. Worm gears are precision ground. There is manual declination with anti-backlash drive.

These are only the most outstanding features. As a whole, the Tinsley 12-inch is a remarkable telescope, the ultimate instrument for schools and colleges, universities, astronomy clubs and even individuals. (Yes, some of these fine instruments have been purchased by individual amateur astronomers.)

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BOOKS AND THE SKY

ORTHOGRAPHIC ATLAS OF THE MOON – PART 1

D. W. G. Arthur and **E. A. Whitaker.** University of Arizona Press, Tucson, 1960. 34 pages. $9.00.

IN current selenographic work, both by professionals and advanced amateurs, much use is made of fairly precise co-ordinates of lunar surface features. They are required for making accurate charts and determining mountain heights or the slope angles of crater walls. Any newly discovered dome or other noteworthy formation is much easier to observe if its co-ordinates are given, instead of some vague verbal description of its location.

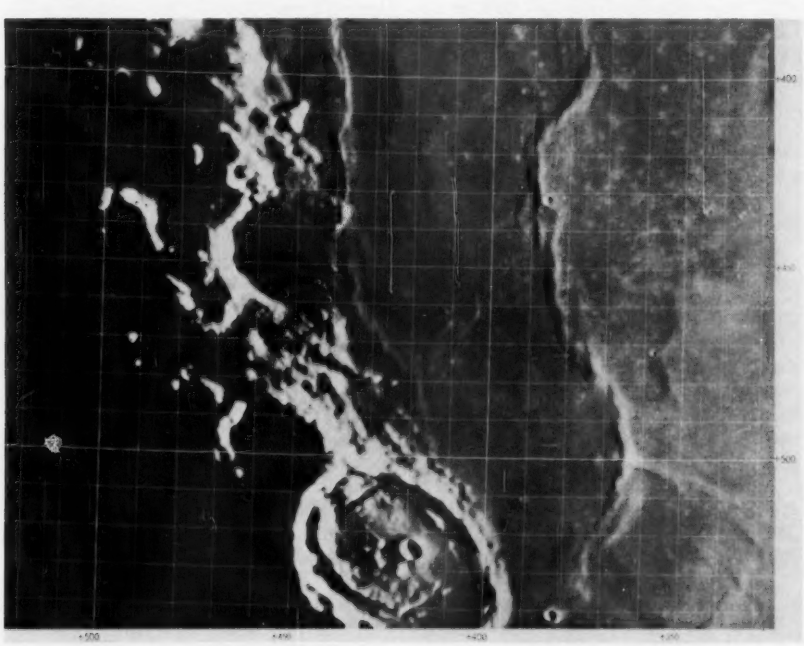
In place of selenographic latitude and longitude, rectangular Xi and Eta co-ordinates (ξ, η) are now in practically universal use. Consider the moon as a sphere, viewed under conditions of mean libration. Construct a plane passing through the moon's center perpendicular to the line of sight to the center; project the moon's surface vertically on this plane. The lunar equator falls upon it as the Xi axis, and the zero meridian as the Eta axis. Xi is counted positive westward, Eta positive northward, and the unit for both is the moon's radius. Thus, the position of the mountain Pico can be given as $\xi = -.106$, $\eta = +.717$.

The International Astronomical Union's lunar atlas of 1935 (now out of print) contains a grid from which the Xi and Eta of features can usually be read with an accuracy of about 0.001. However, this atlas contains only relatively coarse detail. Many amateurs have employed as a substitute H. P. Wilkins' large map, but the smaller features on it are sometimes entered at significant distances from their true places.

The new *Orthographic Atlas of the Moon,* compiled by D. W. G. Arthur and E. A. Whitaker, is intended specifically as a source for reliable positions. Edited by G. P. Kuiper, it forms Supplement Number One to his *Photographic Lunar Atlas.* It consists of two parts, the present one covering the central portions of the lunar disk, while the later installment will provide the limb regions.

Part 1 of the *Orthographic Atlas* is a clothbound loose-leaf portfolio 23 by 18½ inches, containing two pages of text, two pages of key charts, and 29 sheets of gridded photographs. (Part 2 will fit in the same two-post binder.) These are some of the same photographs forming the *Photographic Lunar Atlas,* and represent a selection of the finest pictures taken with the large telescopes at Mount Wilson, Lick, McDonald, Yerkes, and Pic du Midi observatories. The scale is 1:3,700,000, so one inch corresponds to about 21.6 miles near the mid-point of the disk.

On the photographs, grid lines are given at intervals of 0.01 lunar radius in Xi and Eta, allowing easy interpolation to 0.001 or better. This grid has been constructed with great care from about 5,000 standard points measured by S. A. Saunder, J. H. Franz, and Mr. Arthur. The technical details of the process are



A portion of a plate from the "Orthographic Atlas of the Moon—Part 1," reproduced half size, shows the Xi and Eta co-ordinate grid discussed above. This region of the moon's northwest quadrant includes the Serpentine Ridge in Mare Serenitatis and the great crater Posidonius.

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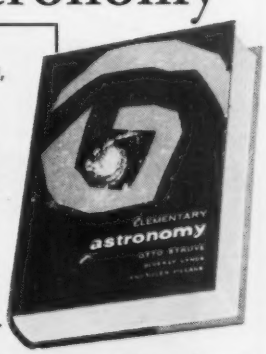

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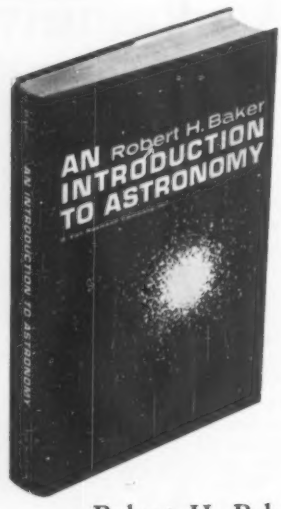

Robert H. Baker's
AN INTRODUCTION TO ASTRONOMY, 6th ed.
376 pages, $5.50

VAN NOSTRAND
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explained in the introduction, where there is also a valuable collection of formulae used in cartography and for determining relative heights of lunar features.

There are two editions of this *Atlas,* edition *A* being that described above. Edition *B,* printed on plastic instead of paper, carries an additional latitude and longitude grid and departs from convention in having north rather than south upward. These last two features are decided inconveniences for practical lunar observers, who should specify edition *A* in ordering copies. The other version seems intended for astronautical rather than astronomical use.

The *Orthographic Atlas* should prove a valuable working tool for the lunar specialist, and indispensable to those engaged in cartography. It is hoped that many regular amateur observers of the moon will also make use of the charts. For example, a drawing published without any indication of scale or orientation can be very difficult to interpret. But the missing information is supplied if Xi and Eta are given for two or three features labeled in the drawing.

J. A.

ASTRONOMY

H. C. King. Franklin Watts, Inc., New York, 1960. 256 pages. $4.95.

IN his foreword the author says: "The time has long passed since one could tell the story of astronomy with completeness in a single book. So rapid and varied have been developments in this science, particularly during the last fifty years, that entire volumes can now be devoted to any one of its individual aspects. Even so, the vast majority of readers anxious to know something about the realm of the stars will turn first to a book on general astronomy. The information found in it will, of course, have been selected and sifted by its author, whose task is to present an overall picture in a lucid and attractive way."

This is precisely what has happened in the writing of *Astronomy.* The author, who is director of the London Planetarium, is a specialist in the history of science, and throughout the book Dr. King's competence in his field is much in evidence. Historical notes complete with names and dates appear in many sections of the book and touch every facet of astronomy.

In the first two chapters, comprising more than 20 per cent of the book, is found the finest exposition. The beginnings of astronomy are traced from the Sumerians through the Babylonians, the Egyptians, and the Greeks. The astronomy practiced then involved the calendar and seasons, and is covered neatly and succinctly. Discovery of celestial motions due to the motions of the earth and observations that gave rise to a better understanding of the sky are portrayed. Finally, the author covers that period of instrumental observing, before the invention of the optical telescope and before discovery of the correct natural laws, that set the stage for explaining the behavior of celestial objects.

A chapter on the tools of astronomy follows. Again, the author's previous position as a senior lecturer in optics is apparent in his authoritative coverage of this subject. The nature of light, the beginnings of the telescope, and the modifications necessary to make it an effective research instrument are summarized. Dr. King writes of the Schmidt camera, new applications of photoelectric techniques, and radio astronomy. We are reminded that he has published a whole book on these topics, *The History of the Telescope.*

The next four chapters involve the parochial subjects in astronomy: the sun, the moon and eclipses, the planets, and comets and meteors. In the chapter on the sun, fault may be found with the art work accompanying the text. While generally acceptable, it is completely inadequate for illustrating solar phenomena. With so many good photographs available, this reviewer does not agree with the use of a substitute for them.

Dr. King has not availed himself of the latest information when he says that spectroscopic studies have so far failed to detect water vapor and oxygen in the atmosphere of Venus. High-altitude balloon flights have succeeded in detecting water vapor there. When he speaks of surface temperatures of the major planets, Dr. King is actually referring to temperatures at the tops of their dense cloud layers.

The stars are treated in an elegant, albeit concise chapter. The author discusses magnitudes, distances, luminosities, spectral characteristics, temperatures, and modes of energy formation in stellar interiors. Likewise, the next chapter on interesting stars and star clusters permits a dissertation on the very small, very large, very dense, and very tenuous.

In Chapter 9, we learn the historical background to our knowledge of the Milky Way, beginning with the work of the Herschels. This section contains an excellent treatment of the "citizens" of our galaxy — nebulae, clusters, and dust clouds.

The last chapter, entitled "Beyond the Milky Way," concerns extragalactic objects, describes types of galaxies, their stellar contents, their motions and associations. This chapter ends on a note of promise of what artificial satellites may do for us.

Many minor errors have crept into the text of this book, as if the proofs had been insufficiently checked before publication. These mistakes will be corrected, we hope, in the second edition.

The book's glossary should be a help

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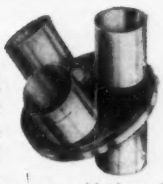

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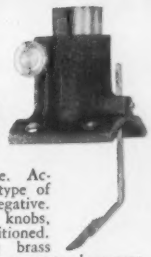

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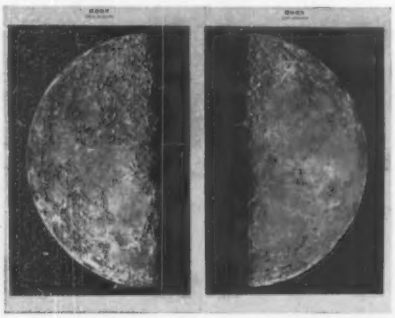

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Atlas Coeli—II, Katalog 1950.0 is the finest check list of celestial objects ever offered the amateur observer. Listed, with descriptive data, are the 6,362 stars brighter than magnitude 6.26, with their right ascensions and declinations, magnitudes, and much other useful information; extensive lists of star clusters, nebulae, and galaxies. Cloth bound, 367 pages. **$8.75**

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to the beginning student of astronomy.

Astronomy is lucid and readable, but those who expect it to contain all the answers will be quite disappointed. The author has skimmed the cream off his subject and presented it in a most palatable fashion. This reviewer, whose duties are similar to those of Dr. King, is sympathetic to the glossy treatment of astronomy, for the average visitor to the planetarium will enjoy and read this book while rejecting standard astronomical texts. There is definitely a reason and a place for this work.

I. M. LEVITT
Fels Planetarium

OPTICS AND OPTICAL INSTRUMENTS

B. K. Johnson. Dover Publications, Inc., New York, 1960. 224 pages. $1.65, paper bound.

REPUBLICATION of the British book *Practical Optics* (second edition, 1947) in a low-cost paper-bound edition makes available to the optical worker and telescope maker one of the greatest bargains this reviewer has encountered in over 25 years. The book is filled with valuable beginner's experiments and with methods of building and using testing equipment. B. K. Johnson presents his topics clearly yet concisely, without sacrificing important principles or ideas.

The reader is first introduced to reflection and refraction, with mirror and lens operation illustrated by experiments that clearly show the paths of light rays through various optical elements. In refraction demonstrations the author employs simple positive and negative spectacle lenses. He gives powers, spacings, and stops to be used for best results, enabling the reader to learn basic optical principles.

The most valuable part of this first chapter is the graphical ray plotter designed by Mr. Johnson for tracing light rays through optical systems. Its operation is based on J. H. Dowell's method, but instead of having to draw an auxiliary diagram for the ray trace, one works directly on the original drawing. I have constructed a Johnson ray plotter and find it invaluable in my work. Learning this approach to ray tracing is alone worth the price of the book.

Focal length measurements are covered in Chapter II. This part of the book is most useful for the amateur who wishes to check his equipment or combine war-surplus optics to make his own instruments or accessories. Clubs will find the foco-collimator described in this section extremely good as a workshop tool.

"The Eye" is the title of the third chapter, which is the shortest in the book but an adequate introduction to the subject.

Chapter IV, "The Telescope," will receive much amateur attention. As a beginner performs the experiments outlined for simple lenses, he will quickly gain a practical knowledge of the operation of various systems. The table on page 68 is of interest to those wondering about the minimum magnification that can exploit the full resolving power of a telescope objective. For a visual acuity of one minute of arc, a magnification of at least 11 per inch of aperture is required with telescopes working at f/10. A section on binoculars aids in their purchase, and tells how to check their performance.

Many amateur astronomers, besides observing the heavens, are curious about the infinitesimal and use microscopes. Chapter V covers microscopy broadly, including photomicrography. Experiments with the simple optical-bench model of the compound microscope on page 84 quickly acquaint the beginner with its operation.

An understanding of the limits imposed by equipment in astronomical photography may be gained from Chapter VI, on photographic lenses. Optical projection systems are covered in Chapter VII, although this subject is generally neglected by introductory books.

"Optical Glass: Its Working and Testing," the last section in this fascinating book, will undoubtedly be of greatest interest to amateur telescope makers. The sections on the spherometer and curvature measurements are of extreme importance, for a good spherometer enables one to hold radii and focal lengths to close tolerances. The ring spherometer is stressed, and is strongly recommended by this reviewer.

A microscope tester for measuring short radii is a simple yet valuable tool for the amateur who wants to make his own eyepieces, which involve extremely short and steep curves.

The method on page 182 for measuring long-radius convex surfaces should prove valuable to those who encounter optical parts of unknown long radii of curvature, for instance, the last surface of an achromatic objective. Although many workers make this surface flat, an occasional objective is correctly manufactured with a long convex back surface, its radius often being over 100 inches.

The auto-collimator on page 190 should prove of interest to clubs as a tool for checking prisms and associated optical components. Naked-eye methods of angular measurement are surprisingly good, and provide the amateur with valuable checks on the accuracy of war-surplus items.

The book's appendix discusses cleaning optical surfaces, cementing lenses, a testing machine for cement and pitch, silvering, reticles, collodion films, waxes and cements, and light sources for optical testing.

It is difficult to do justice here to the excellence of *Optics and Optical Instruments*. In my estimation it is a must for any serious student of optics, especially the beginner.

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49 Bay State Rd., Cambridge 38, Mass.

A GUIDE TO THE STARS

Patrick Moore. W. W. Norton and Co., New York, 1960. 222 pages. $4.95.

DOES your Aunt Matilda wonder why you set the alarm clock for 3 a.m.? Does the junior high school student you are teaching to use his telescope want to know the difference between a globular and an open cluster? *A Guide to the Stars* by Patrick Moore is the perfect book to put into their hands.

This is an extremely readable discussion of celestial objects, and for every type are given examples that are visible to the amateur. The book contains all the topics necessary to understanding the phenomena of the sky, with special emphasis on observing with the naked eye and small instruments. Constellations, the nature of stars, their spectra and distances, and "The Life of a Star" receive attention. There are chapters on binaries and variables, novae and clusters, nebulae and galaxies, and a consideration of the universe as a whole.

The well-known author is an Englishman, as we are reminded by his reference to "the Plough" instead of "the Big Dipper." But Mr. Moore has consciously tried to make the book useful to Americans, and also to readers in Australia and South Africa, who to his envy can see the Magellanic Clouds and other southern objects. The difference between English and American uses of the word billion is just one of the sources of possible trouble that have been avoided.

Special note should be taken of the appendices, which begin with a section entitled "Useful Work for the Amateur," and go on to lists of objects for the beginner at the telescope.

There are few errors of fact, although the author slipped in naming SV Vulpeculae on page 123, and he says on page 118 that both of Beta Lyrae's components are *B* stars, whereas one is of spectral type *F*.

For many readers of SKY AND TELESCOPE, Mr. Moore's book is too elementary. Those who can follow the more technical developments described in this magazine will find the treatment very general. Those who still need better grounding in basic astronomy would profit by reading one of the many excellent introductory college texts available.

Such books are usually written with future study in mind, whereas *A Guide to the Stars* is not helpful in this respect. To take one instance, on page 88 "the dwarf variables" in Orion are mentioned. Does Mr. Moore mean T Tauri stars? If so, naming them as such would enable the reader to connect them with stars of that same sort encountered in later study.

Thus, in some ways it seems a pity that so much readability has been put into a book whose usefulness is limited to the first steps of astronomy.

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NEW BOOKS RECEIVED

TELESCOPES, *Gerard P. Kuiper* and *Barbara M. Middlehurst*, editors, 1960, *University of Chicago Press.* 255 pages. $8.50.

This is the first of nine volumes forming a compendium of astronomy and astrophysics, under the title *Stars and Stellar Systems.* Large reflectors, Schmidt telescopes, photographic zenith tubes, astronomical seeing, observatory site selection, and radio astronomy instruments are among the subjects covered authoritatively by leading astronomers. Lists are given of major optical and radio telescopes in current use.

THE MILKY WAY GALAXY, *Ben Bova,* 1961, *Holt, Rinehart and Winston.* 228 pages. $5.00.

Using nontechnical language, a popular writer tells how astronomers have found out the distances, sizes, and physical natures of the stars. From this he proceeds to a description of star clusters and nebulae, and of the Milky Way system as a whole.

THE ROTATION OF THE EARTH, *Walter H. Munk* and *Gordon J. F. MacDonald,* 1960, *Cambridge University Press.* 323 pages. $13.50.

One of the Cambridge monographs on mechanics and applied mathematics, this geophysical treatise presents observational and theoretical findings concerning variation of latitude, secular changes and fluctuations in the length of the day, and geological evidence for the migration of the poles. There is an extensive bibliography.

PLANETS, STARS, AND GALAXIES, *Stuart J. Inglis,* 1961, *Wiley.* 474 pages. $6.75.

Written by a college instructor in astronomy, this well-illustrated text for general students introduces the world of the astronomer. Each chapter has references for further reading, and there are lists of questions requiring outside study.

BROCKHAUS ABC DER ASTRONOMIE, *A. Weigert* and *H. Zimmermann,* 1960, *F. A. Brockhaus Verlag,* Salomonstrasse 17, Leipzig C 1, East Germany. 400 pages. DM 12.70.

This illustrated German-language encyclopedia of astronomy contains about 1,500 entries: definitions of astronomical terms; brief biographies of astronomers; and short articles on topics in radio astronomy, astrophysics, cosmology, astrometry, astronomical instruments, and space travel. Several folding star maps come in a back-cover pocket, following 16 pages of photographs.

RADIO ASTRONOMY, *F. Graham Smith,* 1960, *Penguin.* 265 pages. $1.65, paper bound.

A British radio astronomer summarizes for the general reader many discoveries in this new science, and describes radio telescopes and how they are used. Well illustrated with diagrams and photographs, the book also contains a listing of the world's radio observatories, present and planned.

RIVAL THEORIES OF COSMOLOGY, *H. Bondi, W. B. Bonnor, R. A. Lyttleton,* and *G. J. Whitrow,* 1960, *Oxford University Press.* 64 pages. $2.25.

In a 1959 series of radio broadcasts, three British cosmologists presented their views on the relativistic, steady-state, and electric theories of the universe. In this book for the general reader their talks have been amplified and clarified. The fourth chapter is a discussion of the rival theories by G. J. Whitrow, who was chairman of the radio symposium.

TOOLS OF THE ASTRONOMER, *G. R. Miczaika* and *William M. Sinton,* 1961, *Harvard University Press.* 294 pages. $7.75.

This latest volume in the Harvard Books on Astronomy replaces *Telescopes and Accessories* by G. Z. Dimitroff and J. G. Baker, long out of print. The present work introduces fundamental optical principles, which are then used in discussing the design of instruments for astronomical research. References are made to many specific telescopes, spectrographs, photometers, and radio receivers in use today. The presentation is aimed at the well-informed amateur.

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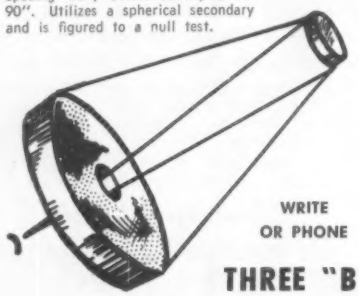

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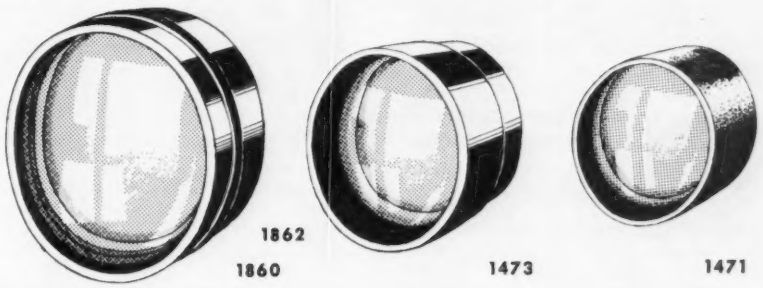

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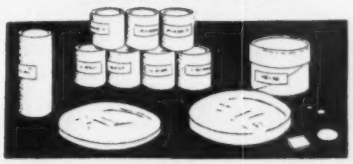

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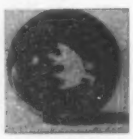

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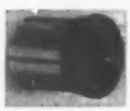
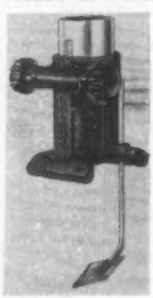


The orthoscopic eyepiece is one of the most important and best corrected eyepieces for astronomical work. These are of a four-element design, with coated lenses, and are standard 1¼" outer diameter, precision made of chrome-plated brass and aluminum.

Stock #30,364-Y	4 mm	**$14.50 ppd.**
Stock #30,404-Y	6 mm	**14.50 ppd.**
Stock #30,405-Y	12.5 mm	**14.50 ppd.**
Stock #30,406-Y	18 mm	**14.50 ppd.**
Stock #30,407-Y	25 mm	**14.50 ppd.**

Rack-&-Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment. Lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors

Stock #50,077-Y..(less diagonal holder)....$8.50 ppd.
Stock #60,049-Y..(diagonal holder only)....1.00 ppd.

For Refractors

Stock #50,103-Y..(for 2⅞" I.D. tubing)...$12.95 ppd.
Stock #50,108-Y..(for 3⅞" I.D. tubing)....13.95 ppd.

FLASHLIGHT POINTER for Movie Screens

Ideal for pointing out interesting features on movie and slide projection screens. Excellent lecture tool. For teacher use on maps, etc. Flashlight focuses an arrow where you point it.

Stock #60,117-Y.....$9.50 ppd.

BINOCULAR-TO-CAMERA HOLDER

For Exciting Telephoto Shots
Will fit any camera

Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing constellations, star clusters, the moon, as well as cloud formations, wildlife, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephoto pictures included.

Stock #70,223-Y.....$11.50 ppd.

Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES

Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum; brackets black crinkle painted.

Stock #70,162-Y.....$9.95 ppd.

PRISM STAR DIAGONAL

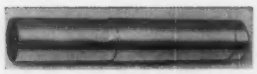
For comfortable viewing of stars near the zenith or high overhead with refracting telescopes using standard-size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path length of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

AMICI-PRISM STAR DIAGONAL

Same as above except contains Amici roof prism instead of usual right-angle prism. Thus your image is correct as to top-bottom, making it excellent for terrestrial viewing.

Stock #50,247-Y.....$12.00 ppd.



NOW! LENS ERECTOR FOR TERRESTRIAL VIEWING WITH YOUR REFLECTOR

This Edmund development adds real convenience to viewing objects on the earth. Just put the lens erector in your eyepiece holder, insert eyepiece, and focus normally. You see everything right side up and correct as to left and right. Made of polished chrome-finished brass telescoping tubing that will fit any standard 1¼" eyepiece holder. Tubing is 9½" long and slides 3" into eyepiece holder. Erecting system consists of two coated achromats.

Stock #50,276-Y.....$9.95 ppd.

STAR TIME CALCULATOR

This handy slide rule automatically makes the conversion from star or sidereal time to standard time. Saves the amateur astronomer the time and trouble of calculations. Size: 10⅓" x 3⅜"; plastic-coated cardboard.

Stock #40,399-Y.....$1.50 ppd.

"MAKE YOUR OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes; polished and aluminized, with lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

OFFSPRING OF SCIENCE . . . REALLY BEAUTIFUL!

CIRCULAR DIFFRACTION-GRATING JEWELRY

A Dazzling Rainbow of Color!

Shimmering rainbows of gemlike color in jewelry of exquisite beauty — made with CIRCULAR DIFFRACTION-GRATING REPLICAS. Just as a prism breaks up light into its full range of individual colors, so does the diffraction grating. Promises to become a rage in current fashion. 1" diam.

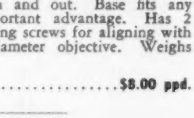
Stock #30,349-Y	Earrings	**$2.75 ppd.**
Stock #30,350-Y	Cuff Links	**2.75 ppd.**
Stock #30,372-Y	Pendant	**2.75 ppd.**
Stock #30,390-Y	Tie Clasp	**2.75 ppd.**

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner eyepiece, type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y.....$7.95 ppd.

6X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 2 holders, each with 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y.....$8.00 ppd.

STANDARD 1¼" EYEPIECE HOLDER

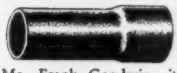
Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.....$2.50 ppd.

Stock #60,049-Y Diagonal holder.....$1.00 ppd.

EDMUND SCIENTIFIC CO.

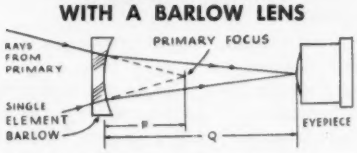
THE ORIGINAL GOODWIN RESOLVING POWER BARLOW



For many years, this achromatic coated Barlow lens has been the pride and joy of serious astronomers. Due to the death of the designer, Mr. Frank Goodwin, it has not been available for the past two years. NOW we can offer these lenses, in exact accordance with the original specifications. Remember, this Barlow is achromatic, coated, mounted in a blackened tube, and as optically perfect as only precision craftsmen can make it. Complete with instructions, in a 4"-long adapter tube for standard 1¼" eyepieces.

Stock #60,122-Y.....**$23.50 ppd.**

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

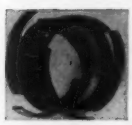
Stock #30,200-Y...Mounted Barlow lens....**$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller-diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.

Stock #30,185-Y....0.932" diam.....**$3.50 ppd.**
Stock #30,328-Y....0.912" diam.....**$2.50 ppd.**

3X ADJUSTABLE-DIAMETER BARLOW LENS



For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" inner diameter. Directions for using included.

Stock #30,339-Y.....**$5.00 ppd.**

MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

Stock #30,370-Y.....**$6.00 ppd.**

BACKLASH-FREE TUNER GEAR CAN BE USED FOR A MANUAL DRIVE ON SMALL TELESCOPES

This inexpensive tuner gear assembly provides completely backlash-free tuning. It can be used for a manual drive on your small telescope. Ratio is 19.5:1, gear assembly capacity 20 inch-pounds. Gear is molded nylon; pinion is cadmium-plated brass. All materials are noncorrosive. It comes completely assembled, less knob. Center distance is 0.548", gear diameter 1.687", pinion diameter 0.418".

Stock #60,180-Y.....**$5.00 ppd.**

ORRERY (Solar System Representation)

Use to show correct positions of planets each month. Sun is represented by 2½" yellow ball, planets by varicolored 3/16" balls. Planets can be rotated freely around Sun. Distance from Sun to Pluto is 16". Base is 6" square. Directions included.

Stock #70,374-Y.....**$15.95 ppd.**

SOLAR SCHEMA

Demonstrates graphically the incredible distances between planets and the comparative sizes of sun, planets, moons. The sun is represented by an 18" vinyl balloon, earth and planets by metal balls in proportion, ⅛" to 1½" diameters.

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CLOCK-DRIVEN EQUATORIAL MOUNT ON PEDESTAL BASE IDEAL FOR YOUR 6" OR 8" REFLECTOR

Accurate electric clock drive and heavy-duty mounting. Operates on household current. Follows stars smoothly. Pedestal is 24" high. Polar-axis shaft diameter 1". Setting circles included.

Stock #85,111-Y.....**$74.50** f.o.b. Barrington, N. J.

Same mount and clock drive on 32" hardwood tripod.

Stock #85,081-Y.....**$69.00** f.o.b. Barrington, N. J.

Same mount on metal pedestal, no clock drive.

Stock #85,108-Y.....**$45.00** f.o.b. Barrington, N. J.

Same mount on tripod, no clock drive.

Stock #85,023-Y.....**$39.50** f.o.b. Barrington, N. J.

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Here they go — all first-class aerial camera lenses and astronomy sets. Priced to go, along with many other real buys, discounted 25 per cent and now discontinued.

AERIAL CAMERA LENS, f/6, 24" f.l. — was $39.50.
Stock #85,059-Y.....While they last.....**$25.00** f.o.b. Utah

ASTRONOMY SET, projects moon travel, eclipses, stellar wonders — was $5.00.
Stock #70,233-Y.....Now **$3.75 ppd.**

DE LUXE ASTRONOMY SET, down from $10.00.
Stock #70,234-Y.....Now **$7.50 ppd.**

GET LISTINGS OF OTHER GREAT SAVINGS IN BARGAIN BULLETIN

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y.....¼" focal length.....**$4.75 ppd.**
Stock #30,203-Y.....½" focal length.....**$4.50 ppd.**

SETTING CIRCLES TO FIT YOUR EDMUND TELESCOPE OR TELESCOPES WITH SIMILAR-SIZED MOUNTS

A — Heavy-Duty

B — Light-Duty

(A) FOR HEAVY-DUTY MOUNT (fits Edmund 6" reflector, 4" refractor). Black plastic. Hour circle has two scales, bottom 0 to 24 hrs., top 0-6, 6-0, etc. Declination circle has numbers every 10°, lines each degree. All filled white. Hole is 1.9"; 3" outer diameter. Two pointers with 2¼" holes.

Stock #60,188-Y.....**$3.00 ppd.**

(B) FOR LIGHT-DUTY MOUNT (fits Edmund 4¼" reflector, 3" refractor). Black plastic, scales same as above. 1"-diameter hole; 3" outer diameter. Two pointers with 1¼"-diameter holes.

Stock #60,187-Y.....**$3.00 ppd.**

SCIENCE PROJECT KITS

MOLECULE AND CRYSTAL MODELS KIT — Rods and balls to make atomic models, plus directions.

Stock #30,413-Y.....**$2.50 ppd.**

SOIL TESTING KIT — Basis for many fascinating experiments regarding growth of plants, etc.

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CRYSTAL-GROWING KIT — Grow breathtaking displays of large crystals with this set.

Stock #70,336-Y.....**$9.50 ppd.**

OPTICAL ILLUSION KIT — Diagrams, lenses, mirrors, etc., for producing many amazing optical illusions.

Stock #70,352-Y.....**$3.00 ppd.**

GIANT ERFLE EYEPIECE 1½" F.L.

War-Surplus Bargain — Gov't. Cost Approx. $100

Large telescopes should have one of these for low-power viewing. Apparent field of view 65°. Also use with our 24"-focal-length Aerial Camera lens to make a 16-power wide-field telescope or a 27-power scope with one of our 40"-focal-length Aerial Camera lenses. Low-reflection-coated, 5-element lens system. Field lens of Eastman Kodak's rare-earth glass for better aberration correction. Has diopter scale. Smooth focusing, ⅜" movement. Outside diameter of attaching threads, 3" — 32 threads per inch. Clear aperture of eye lens 2", field lens 1-25/32". Weight 3½ lbs.

Stock #50,091-Y.....**$9.95 ppd.**

ADAPT GIANT ERFLE TO STANDARD TELESCOPE EYEPIECE SIZE

This adapter lets you use our Giant Erfle with any telescope having a standard 1¼"-diam. eyepiece holder.

Stock #50,358-Y.....**$3.95 ppd.**

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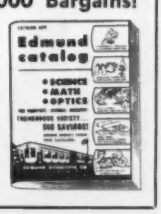
Fantastic variety — rarely before have so many lenses, prisms, optical instruments, and components been offered from one source. Probably the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Many science and math learning and teaching aids.
Write for Free Catalog "Y".



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1. Beral has HIGH reflectivity.
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4. Beral is NOT a Chromium alloy, so can be removed easily.

Prices for Beral coating telescope mirrors: 4", $3.50; 6", $5.00; 8", $6.50; 10", $8.50; 12½", $12.50. Prices for sizes up to 37" diameter on request. Add Postage — Insurance for return mail.

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Reflecting Telescope Kits

De luxe kits contain:
★ 2 mirror blanks of PYREX-brand glass
★ 7 large metal cans of optical abrasives
★ Fast-polishing cerium oxide
★ Red rouge and pitch

Size	*Thickness*	*Price*
4¼"	¾"	$ 6.00
6"	1"	$10.50
8"	1⅜"	$18.75
10"	1¾"	$33.65
12½"	2⅛"	$59.95

ADD POSTAGE: 1st, 2nd, and 3rd postal zones from Detroit, add 10%; 4th, 5th, and 6th, add 15%; 7th and 8th, add 20%; or we will ship postage collect.

Send for free catalog of supplies.

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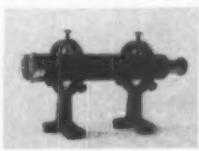
SPIRAL FOCUSER

All-aluminum construction. Takes 1¼"-diam. eyepieces and fits any tube. Drawtube can be locked in place or operated effortlessly with adjustable friction control. $8.95 postpaid. One-arm diagonal holder, $1.50 postpaid.

COATED ACHROMATIC FINDER



Features easy-to-see pointer indicator instead of crosshairs. Large 30-mm. objective. Universal base fits any tube, either reflector or refractor. Focusing provided. Complete with brackets, $9.95 postpaid.

MIRROR MAKING KITS
with PYREX-brand mirror blanks and hard ceramic tools

4¼"	diameter . . .	$5.98 postpaid
6"	" . . .	9.98 postpaid
8"	" . . .	13.98 shipped collect
10"	" . . .	29.98 shipped collect
12½"	" . . .	49.98 shipped collect

Kits include five abrasives, with our special superfine finishing abrasive for superior fine grind, selected pitch, cerium oxide, PYREX-brand mirror blanks, and hard ceramic tools (used just like plate-glass ones). C.O.D.'s accepted.

Used telescopes, binoculars, microscopes, and optics bought, sold, or exchanged.

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GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

Multiple Extrafocal Images of Extended Objects

SOME time ago E. F. Wahlstrom, 4685 E. McKenzie Ave., Fresno 2, Calif., wrote this department:

"The literature on telescope optics includes considerable material on the extrafocal images obtained from reflectors when observing stars, but none on the images of extended objects. I have built an 8-inch f/9 reflector, utilizing a mirror from a well-known maker of fine reputation.

"When I go slowly inside focus, the image of an extended object, such as Saturn, breaks up into two clear images one above the other and overlapping. Further movement away from focus breaks these into multiple images which gradually expand into the usual large round spot of light with the shadow of the diagonal in the center. Going outside of focus, the image breaks up directly into multiple images, nonconcentric but overlapping.

"I have noticed this sort of thing, though varying in detail, with other good telescopes, whereas I would expect a gradual fuzzing up and expansion of the image going out of focus either way. Is this performance indicative in any way of the quality of the mirror? My diagonal is flat to within 1/20 wave and the collimation, painstakingly done, is as accurate as I can make it. As a matter of fact, the better the collimation the clearer the multiple images seem to become."

This correspondence was sent to Prof. Edgar Everhart, of the physics department, University of Connecticut, who is well known for his work on diffraction patterns caused by spider supports in reflecting telescopes (SKY AND TELESCOPE, September, 1960, page 166). Intrigued by Mr. Wahlstrom's problem, he writes from Mansfield Center, Connecticut:

"I repeated Mr. Wahlstrom's experiments in an effort to understand the multiple-image phenomenon. A 10-inch f/11 reflector was used with Venus as a test object under conditions of average seeing. At a power of 90, with 2.8-mm. exit pupil, there was a single well-defined image of the planet in focus. Moving away from focus, both the inside-of-focus and outside-of-focus images became multiple with about 10 fairly sharp overlapping images arranged in a circle.

"A number of tests were then made:

1. When my arm was placed across the aperture opening, the images at the ends of a diameter were suppressed.

2. When the observer's eye was moved laterally, becoming increasingly decentered on the exit pupil, the images disappeared one by one.

3. When a card with a hole one millimeter in diameter was placed before the eye, only one image was seen.

4. The phenomenon was seen at low power, but at high power (500x, with 0.5-mm. exit pupil) the multiple images were definitely not seen.

5. Further and gross defocusing caused the images to blur out into the usual annular ring, whose dark center corresponded to the shadow of the diagonal mirror.

6. Repeating the experiments indoors with Clifford L. Miles, I used a 2½-inch refractor at 12x. The source was a few square inches of fluorescent bulb 150 feet away. Again, multiple images were seen when the refractor was slightly out of focus, their arrangement and number depending on the orientation of the viewer's head.

"From these observations several conclusions may be drawn: a. The phenomenon is seen with both reflectors and refractors, and is apparently not related to optical quality. b. The multiple images are seen only at low power when the exit pupil is large. c. They *do not exist* in the image plane of the telescope; otherwise, one would observe them under high power as well as low.

"Evidently, the eye of the observer is

FOR SALE:

11-inch f/18 Refractor
WITH

- Davis air-spaced achromatic objective, originally intended for the Cincinnati Observatory and purchased by Smith College in 1886.
- Warner and Swasey equatorial mounting with mechanical drive; mechanical slow motions on both axes.
- Three-inch finder telescope.

Instrument, to be replaced by reflector, will be sold at a very reasonable price. Presently completely dismantled. Buyer must pay for crating, shipping, and installation at his location. Best offer accepted. Full details from Astronomy Department, Smith College, Northampton, Massachusetts.

THE MARK III
Sidereal Telescope Drive

Bodine Synchronous Motor, Automatic Clutch, Automatic Sidereal Time Circle requiring no calculation for location of objects, R.A. Indicator, Sidereal Time Indicator, Lifetime Quality, Precision Fabrication.

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the source of the multiple images. With low powers, where the exit pupil is large, a correspondingly large area of the cornea is illuminated with out-of-focus images. Perhaps the eye strains to create focused images in such a way as to distort the cornea or eye lens and cause the multiple images on the retina. At high powers the eye is effectively 'stopped down,' only a small part of the cornea being used to observe the field and only a single blurred image being seen. This suggestion of a distorted cornea as a possible cause was made by Wilbur Widmer.

"Another friend of mine, viewing Mars with an excellent Clark refractor slightly out of focus, once saw six clear images of the planet arranged in a circle, with a seventh image in the center. He tells me he decided at the time not to mention this to anyone!

"The effect seems to be unrelated to seeing conditions, except where seeing may cause images to appear out of focus. Multiple images are not seen when bright stars are observed. Instead, one sees the well-known Fresnel diffraction rings."

R. E. C.

Clock Drive on a Pier

SINCE my simple mounting of thick-walled tubing was described in the January, 1960, Sky and Telescope (page 188), I have completed the clock drive and slow-motion control. Using only war-surplus parts, the total cost was about 10 dollars.

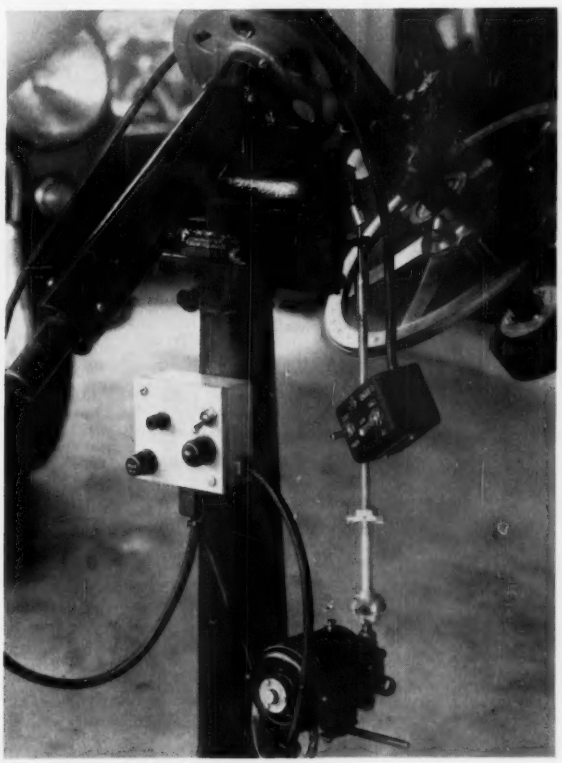
The white junction box on the south side of the pedestal houses an on-off toggle switch, voltage-controlling rheostat, and fuse. Two control lines run from the bottom of the box to the motor and to the slow-motion remote-control switches, which are seen in the box that is dangling at right center in the picture. These controls are a two-way switch for reversing the motor and a self-return switch to allow me to make fine-guiding corrections.

At the bottom is seen the reversible motor, which has an output of 6 r.p.m. at full voltage. The pedestal is rigidly mounted in cement, and motor vibration is further reduced by the single rod that is tapped into the bracket carrying the motor. The telescope remains steady, as any vibration is taken up in this rod.

Rods couple the motor to the polar axle through several universal joints. A pair of right-angle gears provides a reduction of 5 to 1, while the worm and gear reduction is 36 to 1. At full voltage the drive operates faster than the sidereal rate, but this voltage is excellent for slow-motion control. In normal operation, the rheostat is set to reduce the motor speed to the proper rate for stars, or to a different rate if it is needed for the moon or planets.

This drive operates satisfactorily for celestial photographs of up to 30 minutes, but fluctuations in line voltage require adjustment for longer guiding periods.

ROBERT V. JAMES
5430 Jigger Dr.
Soquel, Calif.



Robert V. James's 6-inch reflector has a mounting made of tubing and parts requiring no machine work. They are obtainable at low cost from a welding shop or salvage yard. Besides the versatile drive, a manual slow-motion control is mounted on the declination axis above the large setting circle at upper right. Photo by the author.

OPTICAL TECHNICIANS

WE NEED versatile, research-minded optical technicians with at least five years of experience in fabricating flat and spherical, high-precision optical elements. Must be able to work unsupervised to 1/5 wave or better and to read a test plate. Experience with ultraviolet, visual, and infrared materials desired. Ophthalmic workers, please do not apply.

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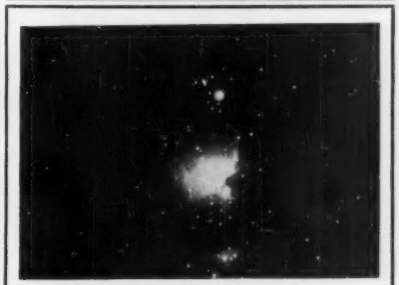

Nebulosity in Orion captured on 35-mm. film in a ten-minute exposure at f/4, using

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Accessories for deep-sky photography also available.

All aluminum and stainless steel, nylon and teflon bearings, spiral focusing, removable Barlow stage for conversion to f/12.

Length: 24 inches.

Weight: 37 pounds, including pedestal-type equatorial mount and electric drive.

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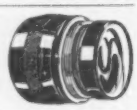

Coated optics. 3 achromatic lenses. 1¼" focal length, 1-13/16" aperture. Price **$12.50**

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Completely mounted with shutter. Originally manufactured for night-photography aerial camera. Film size, 9" x 9". Excellent condition. Price **$50.00**

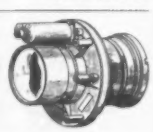
METAL PARABOLOIDAL MIRROR

This is made of hastelloy hard metal. 12" diameter. 5¾" focal length. Manufactured by Bausch & Lomb. Approx. weight, 3½ lbs. Brand-new condition.
Price **$10.00**

LENS ASSEMBLY, 48" FOCAL LENGTH, f/6.3

This was used with the K40 aerial camera, which takes a 9" x 18" plate. Manufactured by Eastman Kodak. Approx. dimensions, 14" diam., 26" long. Contains built-in filters and iris. Lenses mounted in aluminum housing. Approx. weight of unit, 125 lbs. All in original crates. Approx. shipping weight, 200 lbs. Price **$150.00**

BELL & HOWELL f/8 TELEPHOTO LENS



Coated lenses. Focal length 36". Completely mounted with iris and shutter. Approx. weight 25 lbs. Excellent condition. Price **$49.50**

KODAK AERO-EKTAR f/2.5, 6" f.l.

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The clear diameter of front lens is 4"; that of rear lens is 3⅜". The set consists of two metal-mounted elements. Price **$20.00**

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Field of view 8° 45'. Large focusing Erfle eyepiece. Eye lens diameter 2-1/16" with diopter scale +2 · −4. Four built-in filters — clear, neutral, red, amber. Length 15⅞", width 6⅛", height 7¼", weight approx. 9½ lbs. Excellent unused condition. Price **$39.50**

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Produces visible image from infrared image in complete darkness. For seeing in dark with infrared light source. Nothing to wear out. Operates on two flashlight batteries. Has high-voltage power supply and image tube (1P25) and elaborate optical system. Weighs only 6¼ pounds and is only 11" long, 8" high, 5½" wide. Manufactured by R.C.A. Objective f/0.9 Schmidt system, 2.4" focal length, 3¼" aperture. Excellent condition, with waterproof carrying case. Price **$35.00**

INFRARED FILTERS

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Focal length 24". Completely mounted with iris and shutter. Excellent for wide-field telescope. All in excellent condition. Price **$25.00**

GOVERNMENT-DESIGNED ERECTING EYEPIECE

The eyepiece system is housed in a precision barrel, with provision for varying the separation of the components and the magnification. The combination consists of a Kellner eyepiece of approximately 25-mm. focal length in tandem with a pair of achromatized doublets. This latter unit has a focal length of about 25 mm. and functions as the erector, or as a symmetrical eyepiece when used alone. The erector system is mounted in a threaded cell which may be turned in or out to vary the spacing and power. The entire assembly has a focal length of about 10 mm., and when used complete or in increments yields hard, wire-sharp images. 1-3/16" in O.D. by 4¾" in length; equipped with a rubber eyeshield.
Price **$5.95**

8-POWER ELBOW TELESCOPE

2" objective; Kellner eyepiece; Amici erecting prism; 4 built-in filters; reticle illumination; field is 6° (325 ft. at 1,000 yds.). The focusing 28-mm. eyepiece allows focus from 15 ft. to infinity. Weight, 5 lbs. These were used by the government for antiaircraft. Government cost over $200.00. Price **$12.50**

5" SCHMIDT ULTRA-HIGH-SPEED OBJECTIVE LENS SYSTEM

Eastman Kodak infrared receiver, formerly known as U. S. Navy Metascope. Type B. 7" long with 5" Schmidt ultra-high-speed objective lens (approx. f/0.5). Elaborate optical system, many coated lenses. Uses two penlight batteries. Cost government approx. $300.00. Factory-new. Shipping weight 9 lbs. Price **$19.95**

Waterproof carrying case extra. Shipping weight 3 lbs.
Price **$3.00**

f/8 40" AERIAL CAMERA LENS

Mfgd. by Bausch & Lomb. Completely mounted with iris. Original negative size 9" x 9". In excellent condition. Price **$50.00**

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Completely assembled with coated lenses. Focal length 22.5 mm.; used on 6 x 30 binoculars. Price **$3.95**

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Manufactured by Bell & Howell (200 series). 50' magazine load. Operates on 12-volt d.c. Has rotary solenoid, standard C mount, less lens and view finder. Excellent for photographing records, nature study, and so forth.
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24-hr. dial and civil date indicator. Center sweep second hand. Luminous figures and hands on black face. Case is made of black plastic. 3⅛" mounting. Mfgd. by Waltham Watch Co. Price **$20.95** postpaid

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Bulb type (with alternate averaging device). Mfgd. by Bendix. Unit contains a horizontal indicator, a precision averager (for two-minute readings), an astigmatizer lens, bubble-level prism, spring-wound motor, etc., with carrying case. Shipping weight 20 lbs.
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Mounting Diagonal Mirrors with Cement

THE DIAGONAL MIRROR of a Newtonian telescope is generally held in place by several small clips that extend over the front edges and keep the glass in its mounting tube or on a 45-degree holding block. To avoid the diffraction effects that these clips might cause, I decided to attempt cementing the small flat to its support.

However, there is little or no literature on how to do this; in fact, almost every person contacted for advice strongly opposed the idea. Dire predictions were made of figure distortion and ultimate disaster in the diagonal falling upon the primary mirror. Nevertheless, I went ahead with tests of cementing the glass diagonal to a felt backing, which in turn would be cemented to a metal plate. This arrangement should allow for differential expansion of the glass and its supporting parts.

Three products were tried: Duco household cement, Goodyear Pliobond, and Weldwood contact cement. For the first test, pieces of aluminum plate (from an old radio's variable capacitor), felt, and window glass were bonded in a sandwich. Part of the metal was allowed to overhang the glass so a good grip could be taken on it when trying to separate them from one another.

The samples, with the glass sides up, were exposed to hot sunlight for several hours, then placed in a refrigerator at 38° Fahrenheit during a whole night. The cycle was then reversed, cooling first and then exposing to the sun. After this cycle of temperature extremes, an attempt was made to separate each sandwich with reasonable force, two or three pounds. They held tight with no indication of loosening, although I could see and feel a slight movement. A magnifying glass showed that the felt fibers were moving but not letting go. The tests were repeated several times over a three-week period with similar results, indicating that the cement bond was probably permanent.

To compare the cements themselves, I daubed a bit of each on glass and subjected them to the same temperature cycles as the sandwiches. When poked with a small screwdriver, the Duco flipped off in one piece; the Pliobond yielded to heavy pressure, but did not come off; the Weldwood behaved like the Pliobond, but of the two it seemed to be slightly softer.

There seems no doubt that the Weldwood contact cement will hold a diagonal safely, although the Pliobond will probably do as well even if it sets somewhat stiffer. I have cemented my diagonal in this manner and have complete confidence that it will hold. Of course, there is the question of aging of the cement, and some time in the future I will run

the test sandwiches through the hot and cold cycles again.

The felt requires departing from the manufacturer's instructions for using the Weldwood cement, which are to apply it to both surfaces and let them dry for 15 or 20 minutes before placing them together. But the felt soaks up the cement and becomes stiff and hard, so I applied the Weldwood only to the metal surface, putting the felt on it immediately and allowing it to dry for an hour or more. Similarly, the cement was applied to the back of the diagonal, and the sandwich pressed together at once, followed by a long drying period.

The work is now thoroughly set and dry; the felt is still resilient, the glass moving slightly when wiggled, but the bond is tight. With the cemented diagonal in my 6-inch reflector, there is no detectable image deterioration. On one occasion I have successfully used 300 power, although observing conditions where I live are far from ideal, and such a high power is seldom employed.

JOHN M. KIEFER, JR.
32 Hawthorne Ave.
Bloomfield, N. J.

AN AID TO FIGURING PERFORATED MIRRORS

IN a Cassegrainian or Gregorian reflector, the primary mirror has a central hole for passage of the converging light from the secondary to the focus behind the primary. Modern workshop methods call for partial perforation before such a mirror is figured, that is, for cutting the hole from the back of the blank to within a fraction of an inch of the front surface. The central core is thus retained in position while the optical work goes on, the final cutting out being done after polishing is completed.

Unfortunately, the partial perforation acts as a barrier to heat transfer between the core and the disk as a whole. During polishing, heat collects at the center, either causing a hill to develop there or raising a ring coincident with the edge of the core. These irregularities make it difficult, if not impossible, to use this area as a reference point for testing.

While figuring a 12½-inch Cassegrainian primary at the Adler Planetarium in Chicago, I completely eliminated this undesirable effect by the simple expedient of filling the cylindrical cut with a few grams of mercury metal, sealing it with molten paraffin wax dispensed from a tablespoon. Presumably the mercury, being a good conductor, efficiently transfers heat from the core to the rest of the blank. The entire mirror behaves as if it were not perforated, and may be successfully figured.

Mercury should be handled with care, as its vapor is toxic.

R. ZUSSMAN
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When you build the 6" Cleveland, all of your money goes into high-quality parts — none into the cost of assembling, painting, collimating, or packing and shipping a complete telescope. Our clear instructions make it easy (and fun) to do the work yourself with ordinary tools. And there's no need to search out unrelated parts and make them fit, because every Cleveland part is a component of a balanced design, engineered to *match* and machined to *fit*. They go together quickly to make a fine instrument you'll be proud to own — and at a substantial saving.

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FEATURES: Rotating base permits easy alignment and locking on north. Rotating tube with positive-locking tube clamp. Husky, vise-grip latitude adjustment is easy to set, stays put. Rigid, high-strength aluminum construction. No rust. Extra-long bearings and large brakes give precise control. Legs open to fixed position, close easily for carrying. Parts machined to close tolerance for smooth, trouble-free operation. Easily assembled with simple tools.

EQUATORIAL MOUNT Heavy-duty 12" saddle, tube clamp, axle bearings, rotating base, tripod top, tapered channel legs, and extra pier top are cast aluminum. Axles are 1¼" ground and polished steel. Bearings are 5½" long. Large-area brakes, knurled bronze-aluminum alloy adjusting knobs. Brass thrust washers at all friction points. Knurled knobs lock rotating base in V groove in tripod top, release for easy transfer to permanent pier. Latitude adjustment 0° to 55°. Cadmium-plated latitude and leg bolts, nuts and washers. Weight 23 lbs. For 6" telescope ..... $79.50 f.o.b.

For 8" telescope (specify tube O.D.) ..... 89.50 f.o.b.

COUNTERWEIGHT 12½ lbs., 1" or 1¼" bore ..... 5.95 f.o.b.

EXTRA PIER TOP for permanent mount ..... 5.95 f.o.b.

ALUMINUM TUBE 7" O.D. x 60" x .064" wall ..... 14.85 f.o.b.

6" MIRROR CELL Solid plate protects mirror. Ring housing reduces convection currents. Improved clips hold mirror without pressure. Shockproof, cushioned adjustments prevent vibration, keep mirror in collimation. No springs. Cast aluminum, machined for 7" O.D. tube. Attaching screws included ..... 8.35 ppd.

8" MIRROR CELL Same adjustments as 6" cell, but housing fits inside tube. Specify tube I.D. when ordering ..... 11.95 ppd.

DIAGONAL HOLDER Fully adjustable, shockproof design. One turn moves mirror .050". Three screw adjustments give perfect control of mirror angle, make collimating easy. For 1¼" x 1¾" elliptical diagonal mirror. Fits 7" tube ..... 7.95 ppd.

For tubes up to 10" diam. Specify tube I.D. ..... 9.15 ppd.

1¼" EYEPIECE HOLDER Acme-threaded brass sleeve in accurately machined aluminum housing gives smooth, micrometer-sharp focusing. Only one moving part. Stays where you set it ..... 7.95 ppd.

SETTING CIRCLES 5" cast aluminum with machined faces. ½"-wide matte-white scales have accurate black graduations and large, legible figures. ½" to 2" bore. Attach with setscrews. Specify shaft size. Pair ..... 12.75 ppd.

6" MIRROR Pyrex, f/8 parabolic, hand figured to 1/10 wave or better. 48" focal length plus or minus up to 1¼" ..... 62.50 ppd.

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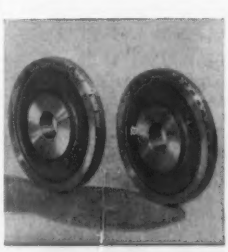
EYEPIECES 1¼" Brandon orthoscopic oculars available in seven sizes: 4, 6, 8, 12, 16, 24 and 32 mm. Each ..... 15.95 ppd.



ALL MECHANICAL PARTS, including setting circles, and complete instructions for building the 6" Cleveland ..... 129.75 f.o.b.

ALL OPTICAL PARTS Mirror, diagonal, and one Brandon orthoscopic ocular of your choice of focal length ..... 82.45 ppd.

6" CLEVELAND TELESCOPE including one Brandon eyepiece of your choice of power, assembled, painted, collimated, ready for use and packed for shipment ..... 244.50 f.o.b.

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CLEVELAND ASTRONOMICS

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constellation of the month

LEO

On warm, clear April evenings the handsome constellation of Leo rides well up the southern sky. The head and forepaws of the Lion are marked by a famous sickle-shaped line of stars, with 1st-magnitude Regulus in the handle of the Sickle. At the eastern end of the constellation is a triangle of stars forming the hindquarters of Leo, and it takes only a little imagination to outline the giant beast.

The neighborhood of Regulus deserves watch by amateurs who use binoculars, for this year it is the region of the planet Uranus. Month by month the slowly moving planet nears the star, finally passing half a moon's breadth north of it in mid-October, when Regulus and 6th-magnitude Uranus will appear as a very wide "double star" in binoculars and finders.

With a 2.4-inch UNITRON, Regulus itself is an actual double, the brilliant primary having an 8th-magnitude companion distant 3 minutes of arc. Another pair, considerably closer but easy to resolve with medium powers on modest-size UNITRONS, is 54 Leonis, magnitudes 4½ and 6½, with a separation of 6 seconds.

Owners of 3-inch and larger UNITRONS will want to try the magnificent close double star Gamma Leonis, whose components are magnitudes 2 and 4, separated by 3 seconds. A fairly high power on a night with steady seeing is recommended. For double star work, the UNIHEX is a very convenient accessory; first center the star in the field of your lowest-power ocular, then a flick of your finger gives an instant change to any high-power eyepiece you select.

Leo is a region rich in galaxies — small, faintly luminous patches that are actually extremely remote Milky Ways whose light takes millions of years to reach us. Amateurs with 4-inch refractors are well-equipped for galaxy hunting, and the superior light-gathering power of 6-inch UNITRONS makes them especially effective. Five of the galaxies in the historic Messier list lie inside Leo: M65, M66, M95, M96, and M105.

UNITRON VIEW FINDERS

1. **VIEW FINDER,** 23.5-mm. (.93"), 6x eyepiece. **Only $8.50**
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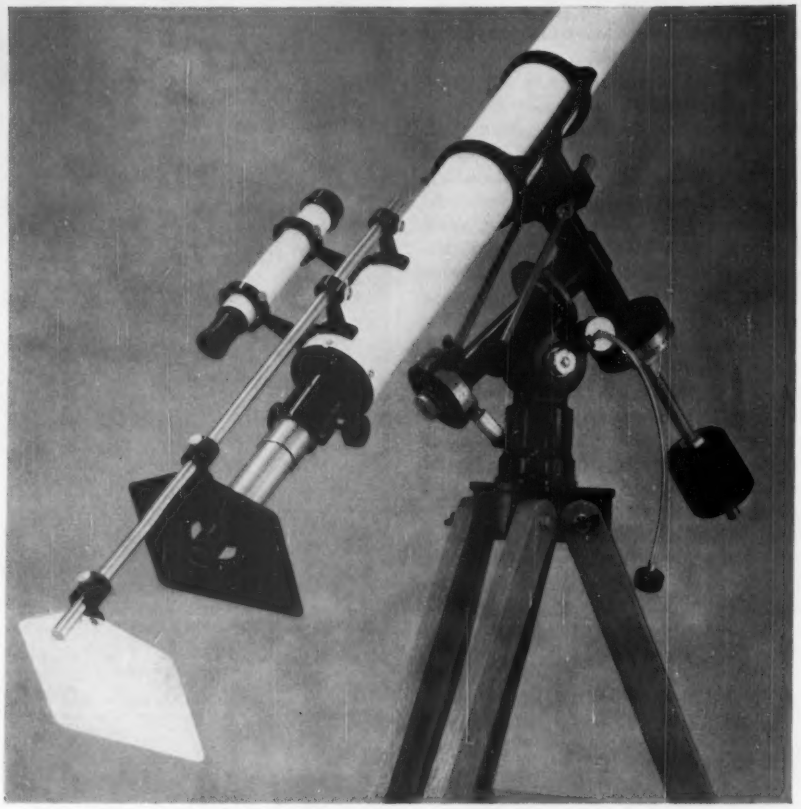
3. **VIEW FINDER,** 42-mm. (1.6") air-spaced objective, 10x eyepiece. This finder measures approximately 16" over-all. It is light in weight, compact, and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky. **Only $18.00**

UNITRON of the Month ..... Model 142



Here is one of our most popular refractors for the serious amateur astronomer who wants a portable equatorial. The UNITRON 3" Model 142 comes complete with equatorial mounting and slow-motion controls for both declination and R.A., setting circles and verniers, tripod and shelf, 8x, 30-mm. view finder, choice of UNIHEX Rotary Eyepiece Selector or star diagonal and erecting prism system, sun projecting screen apparatus, sunglass, pocket eyepiece case, cabinets, five eyepieces and the new Achromatic Amplifier. This professional-quality UNITRON is priced at only **$435.00**

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Send check or money order in full or use our Easy Payment Plan. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back. Prices of UNITRON refractors include basic accessories, eyepieces, tripod and mounting, fitted cabinets, and instructions.

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UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is cancelled.

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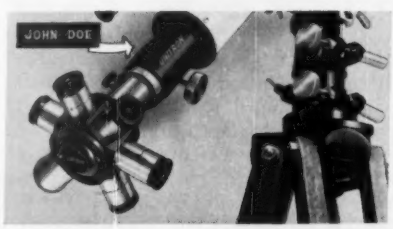
We've gone and done it. We've personalized the telescope business. For a limited time, when you buy a UNITRON, you can have your name embossed in a plastic name plate attached to the gleaming black barrel at no charge.

People tell us they like it. It's in quiet good taste, yet it seems to give that extra fillip to the pride of ownership people feel for their UNITRONS. To get your name plate simply add this statement to your order: Please attach a name plate to my telescope. This is the name: (print name clearly).



UNITRON

INSTRUMENT COMPANY • TELESCOPE SALES DIVISION, 66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Rotcarfer and Rotcelfer — A folk tale too grisly for Grimm

Everyone is familiar with Grimm's Fairy Tales — even children. Less widely known is the fact that these stories of fantasy and magic were the by-product of serious philological research. The Grimm brothers, Jacob and Wilhelm, recorded these popular tales from old manuscripts and garrulous grandmothers while studying the structure of early Germanic languages. Their collection includes such favorites as *Snow White, Rumpelstiltskin,* and *Cinderella,* but for some uncanny reason no mention is made of *Rotcarfer and Rotcelfer.*

Why this lapse from German thoroughness? A brief summary of the plot of this forgotten folk tale will suffice to prove that it is hardly lacking in the elements needed to insure a wide acclaim and lasting fame.

Once upon a time there were two brothers, Rotcarfer and Rotcelfer (not to be confused with Jacob and Wilhelm) who dwelt in harmony in a valley hut at the edge of the woods. One day in the forest while rummaging among some fallen leaves in search of a lost beanbag, they chance upon a gnome engaged in guarding a small cache of gold. Fearful that our Bavarian Bobbsey Twins might blabber the whereabouts of this miniature Fort Knox, the gnome pledges them to silence in return for a shiny gold coin. The brothers' joy is without bounds, since this blackmail money will buy what they have always dreamed of owning — an astronomical telescope.

But, alas, dissension soon develops — for Rotcarfer wants a refractoR, and Rotcelfer a reflectoR. All the way home they debate the relative merits of the two types of telescopes. Rotcarfer argues that the open-ended tube of the reflector is ill-suited for use in their locale; that the cold night air sweeping down the mountainside into the valley generates turbulence and will produce unsteady images. Indeed, he points out, it is likely that their mother would hurry them off to bed long before thermal equilibrium will have been attained. He further maintains that on those nights when turbulence is not serious they will be plagued instead by internal dewing of the optics, and re-

minds his brother that certain varieties of dew, said to originate as the tear drops of ogres, are known to be corrosive to silvered surfaces.

Rotcelfer, on the other hand, reasons that a reflector is bound to possess certain magical features not found in a refractor. He recalls how the Wicked Queen, the stepmother of Snow White, used a mirror as a sort of primitive radar to keep posted on the identity of the "fairest in the land." Each logical argument advanced by one of the disputants leaves the other unconvinced. To break the deadlock, they agree to let a toss of the gold coin decide the choice of a telescope.

> Gold coin, gold coin, on thee we call.
> Pray determine by thy fall
> Whether objective achromatic
> Or, instead, mirror parabolic.

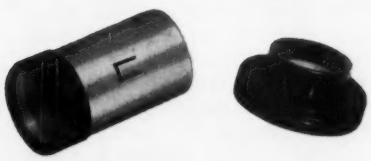
(As you might guess, the verse has suffered somewhat by translation.)

Alack the day! Once airborne, the coin appears to have been endowed by the gnome with satellite tendencies and it sails out of sight into orbit, never to be seen again. It just goes to show that you can't trust a gnome. Our heroes, refraclectorless but wiser, are left to live miserably ever after.

Dry your tears — lest you dampen the UNITRON ad on this page — while we return to the question of the omission from the Grimm collection of this moving tale of bathos. Some have speculated that it contained classified information and was suppressed for security reasons. Others have felt it may have been withheld for fear of jeopardizing Gnomo-Germanic relations. Cogent as these reasons may be, we ourselves can find satisfaction only in a completely scientific explanation and hence turn to number, the language of science.

In 1785, Jacob Grimm was born and one year later, in 1786, Wilhelm. Who then was born in the following year of 1787? Why none other than Joseph von Fraunhofer, whose pioneering work with achromatic objectives and equatorial mountings qualifies him as the father of the modern refractor and the godfather of UNITRON. Is it not likely that the great German optician, a victim in his apprentice days of the mirror maker Weichselberger, a contender in later years against his coworker Guinand, aware of the squabbles among contemporary lensmakers, had, out of these experiences, reasoned that this tale of telescopic contention might best be left unrecorded for the good of astronomy? Had he communicated this opinion to the brothers Grimm, these known paragons of gentleness could hardly have failed to respond with less than fatherly sympathy to a plea from their younger compatriot. They would have most certainly agreed to relegate the two "reds," Rotcarfer and Rotcelfer, to the realm of the unread. If there be among our readers any gnomes who remain unconvinced by this gnostic reasoning, let them offer a better explanation.

NEW ACHROMATIC AMPLIFIER NOW FREE with each UNITRON



UNITRON's new "Achromatic Amplifier" is a two-element, Barlow-type, negative amplifying lens designed especially for UNITRON Refractors. When used with a UNITRON eyepiece, it **doubles** the normal magnification of the telescope. Here is an ideal way to increase the usefulness of each eyepiece and to obtain the high magnifications that you have always wanted for planetary and lunar observations. The magnification factor of 2x has been selected as the most useful for general amateur observing under a wide variety of atmospheric conditions.

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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

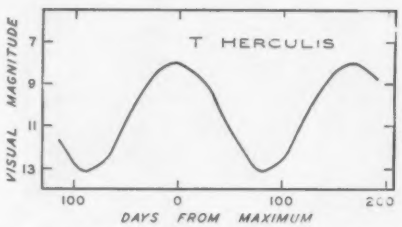
T HERCULIS

DURING late evenings in April, as Hercules ascends the eastern sky, the famous Mira-type variable star T Herculis will be conveniently placed for observation in small telescopes. This spring, maximum brightness is expected about April 6th. In an average 165-day cycle, T Herculis oscillates between magnitudes 8.0 and 13.1, according to Leon Campbell. Hence its changes are unusually rapid for a variable of the Mira type, being conspicuous from week to week.

Successive cycles of T Herculis can differ appreciably in amplitude and duration. During the years 1921-49, some maxima were as bright as magnitude 7.1, others as faint as 8.8, and the intervals between consecutive maxima ranged between 156 and 176 days. According to observations by members of the American Association of Variable Star Observers, the last two maxima took place in 1960 on May 6th (magnitude 7.6) and October 22nd (8.4). Nearly midway between these peaks, the star faded to slightly fainter than magnitude 13.0.

The 1950 co-ordinates of this variable are $18^h\ 07^m.2$, $+31°\ 01'$, not far from Xi Herculis. The color of T is a paler red than that of most other Mira stars, one indication of the general rule that redness and period length are correlated in variables of this type, longer periods being associated with deeper color.

T Herculis is one of the 800 to 900 variable stars whose brightness changes are kept under observation by the 600 AAVSO members, mainly amateurs. Systematic estimates of brightness are made with the aid of special charts supplied at cost by the society. This work affords amateurs without specialized equipment an opportunity to make useful contributions to astronomy. Observers wishing information should write to the American Association of Variable Star Observers, 4 Brattle St., Cambridge 38, Mass., mentioning size of telescope and extent of observing experience.



Published in Leon Campbell's "Studies of Long Period Variables," observations by members of the American Association of Variable Star Observers were used to compile this light curve for the Mira-type star T Herculis. Its average period is quite short for a star of spectral type M.

APRIL METEORS

This month's meteor shower, the Lyrids, is connected with a long-period comet observed 100 years ago. Observations of the sparse shower on April 20-22 will not be impeded by the first-quarter moon; maximum will occur about 4^h Universal time on the 22nd. Some 15 meteors per hour may be noted by a single observer during the time of maximum, perhaps eight of these being members of the shower.

WILLIAM H. GLENN

VARIABLE STAR MAXIMA

April 6, T Herculis, 180531, 8.0; 7, S Herculis, 164715, 7.6; 10, R Geminorum, 070122a, 7.1; 14, R Horologii, 025050, 6.0; 16, R Draconis, 163266, 7.6; 19, R Centauri, 140959, 5.9; 20, V Canum Venaticorum, 131546, 6.8; 22, S Ursae Majoris, 123961, 7.8; 26, R Aquilae, 190108, 6.1.

May 7, V Cassiopeiae, 230759, 7.9; 9, T Columbae, 051533, 7.5.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MINOR PLANET PREDICTIONS

Thetis, 17, 10.3. April 1, 14:29.1 −4-44; 11, 14:22.8 −3-44; 21, 14:14.6 −2-45. May 1, 14:05.8 −1-56; 11, 13:57.6 −1-24; 21, 13:51.1 −1-12. Opposition on April 25th.

Thia, 405, 10.5. April 11, 15:19.3 −32-13; 21, 15:15.1 −31-18. May 1, 15:08.5 −29-52; 11, 15:00.8 −27-59; 21, 14:53.7 −25-51; 31, 14:48.7 −23-42. Opposition on May 9th.

Hygiea, 10, 9.5. April 21, 15:44.5 −24-34. May 1, 15:38.0 −24-14; 11, 15:30.3 −23-44; 21, 15:22.1 −23-06; 31, 15:14.5 −22-25. June 10, 15:07.5 −21-45. Opposition on May 15th.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MOON PHASES AND DISTANCES

Full moon	April 1, 5:48
Last quarter	April 8, 10:16
New moon	April 15, 5:38
First quarter	April 22, 21:50
Full moon	April 30, 18:41
Last quarter	May 7, 15:58

	Distance	Diameter
April		
Perigee 11, 8^h	228,500 mi.	32′ 29″
Apogee 23, 10^h	251,200 mi.	29′ 34″
May		
Perigee 6, 12^h	229,600 mi.	32′ 20″

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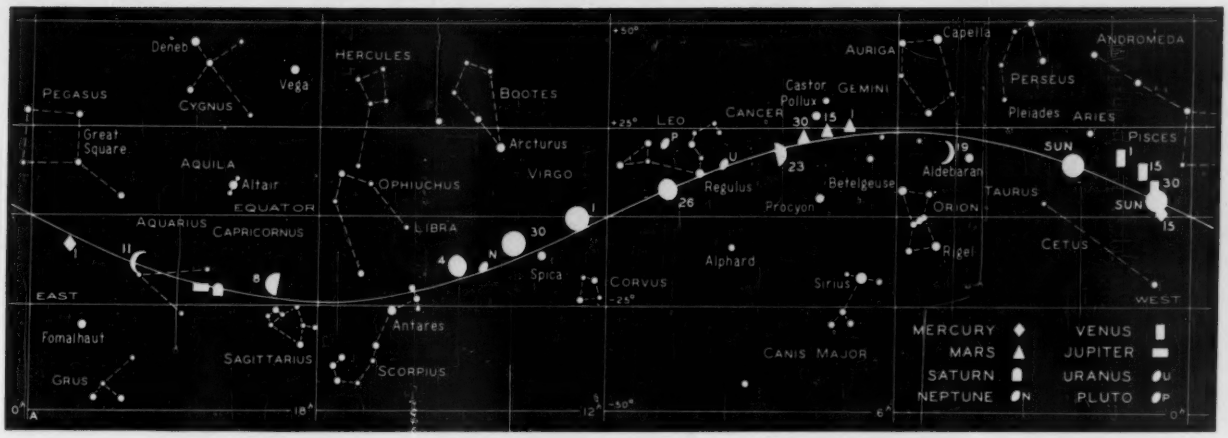

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury is too near the sun in the morning sky for amateur observation this month.

Venus at the beginning of April sets about 1½ hours after sundown. As the month progresses, this brilliant evening object rapidly approaches the sun, inferior conjunction occurring on April 11th. Surprisingly, Venus may be seen in the morning sky just before sunrise a few days previous to this, because of its distance north of the sun. By the 30th the planet will be a thin crescent, with 11 per cent of the 50″.2-diameter disk illuminated. The planet will then be of magnitude −4.0 and will rise nearly 1½ hours before the sun.

Mars moves eastward through Gemini this month, decreasing in brightness from magnitude +0.9 to +1.3 and in diameter from 7″.3 to 6″.0. It reaches eastern quadrature on April 4th, being visible in the western sky during the evening and setting 1¾ hours after local midnight.

Jupiter rises more than three hours before the sun, a bright planet of magnitude −1.8 in Capricornus. On the 15th, a telescope will show the planet's disk to be 35″.2 in polar diameter and 37″.7 in equatorial. Western quadrature occurs on April 26th.

Saturn, magnitude +0.8 this month, precedes Jupiter in the southeastern morning sky by nearly 5½° in mid-April. At that time Saturn's disk is 16″.6 in equatorial diameter, and its ring system shows a major axis 37″.3 across. Western quadrature will be reached on the 19th. The moon will be near Saturn and Jupiter on the morning of April 9th, passing about 3° north of them.

Uranus, in Leo, is at right ascension 9^h 36^m.9, declination +15° 01′ (1950 coordinates) on the 15th. The retrograding 6th-magnitude planet crosses the meridian about 1½ hours after sunset, and during much of the night may be seen in the western sky with binoculars. Stationary in right ascension on the 29th, Uranus will then resume direct (eastward) motion among the stars.

Neptune will be 2,724 million miles from the earth at the time of its opposition on April 30th. Rising about sunset, the 8th-magnitude planet is in Libra and may be seen with telescopic aid throughout the night. On the 15th its 1950 co-ordinates are 14^h 33^m.6, −13° 09′.

WILLIAM H. GLENN

UNIVERSAL TIME (UT)

TIMES given in Celestial Calendar are Universal time (Greenwich civil time) unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

MINIMA OF ALGOL

April 2, 17:46; 5, 14:35; 8, 11:24; 11, 8:13; 14, 5:03; 17, 1:52; 19, 22:41; 22, 19:30; 25, 16:20; 28, 13:09.

May 1, 9:58; 4, 6:47; 7, 3:36.

These minima predictions for Algol are based on a recent timing by D. Engelkemeir, and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

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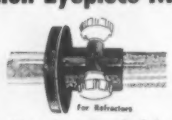

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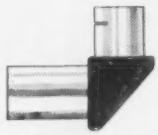

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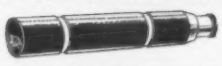

Newly designed wide-field finderscope for reflector or refractor. Featured in this handsomely conceived black anodized aluminum tube are a 30-mm. coated achromatic objective, a wide-field Kellner eyepiece, and the all-important true crossline reticle for fast, exact locating. Compact and lightweight, 9" long, 1½" diam., 9 oz. May also be used as a hand-held telescope, offering excellent extra-wide-field views of the sky.

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Made of cast aluminum with black crackle finish. Each ring has three locking wing screws for adjusting. Base has two holes for mounting screws, and fits any diameter tubing. Easy to attach. Ring mount No. S1963 will accommodate finder above.

Cat. No. S1963 .. 1-15/16" I.D. .. **Per Pair, $3.95 ppd.**
Cat. No. S1964 .. 2-11/16" I.D. .. **Per Pair, 3.95 ppd.**

New Prismatic Telescope

Coated **80-mm. Objective**

Big 80-mm.-diam. (3⅛") objective, for spotting or astronomical use. Will show stars of the 11th magnitude — 100 times fainter than the faintest visible to the naked eye. Table-top tripod included, extended 18", closed 13¼". Length of scope 16¼". Combined weight of scope and tripod is 5¼ lbs. All coated optics.

FIVE EYEPIECES

Power	Field at 1,000 yards	Exit pupil diam.	Relative Brightness
15x	122 ft.	5.4 mm.	29
20	81	4.0	16
30	61	2.7	7
40	49	2.0	4
60	32	1.3	1

Cat. No. S2052 ..... **$59.50 ppd.**

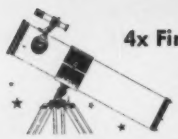
60-mm.-diam. Scope. Same as above but with smaller objective. Equipped with same five eyepieces — 15x, 20x, 30x, 40x, 60x. Coated. With tripod.

Cat. No. S1721 ..... **$42.95 ppd.**

4" Reflector Telescope

45x-225x

4x Finder — Wood Tripod



Study the sun and its spots. Observe galaxies, clusters, nebulae, and the Milky Way. Enjoy the thrill of being able to pick out small craters on the moon and see detail in the larger craters. A beautiful lunar landscape is brought to your doorstep. Bring distant events close to you; witness nature in action — eclipses, heavenly objects, and orbiting satellites. A high-quality telescope with an f/9 mirror. It has three eyepieces, 4-mm. (225x), 6-mm. (150x), 20-mm. (45x), and a free Barlow lens which will double the power. This will give 90x with the 20-mm. eyepiece, and 300x with the 6-mm. if observing conditions permit. Equipment tray keeps eyepieces clean and at hand. Sun and moon filters are included. Collapsible wood tripod makes scope portable, gives it stability and compactness. Finished in gray enamel with black trim. Imported. Shipping weight about 20 lbs.

FREE BARLOW LENS PLUS FREE BOOK "DISCOVER THE STARS" will come with scope.

Cat. No. S2273 ..... **f.o.b. Lynbrook, N. Y., $59.50**

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Cat. No.	Size	Field at 1,000 yards	Type	Price, ppd.
S1149	6 x 15 IF	360 ft.	Opera	$12.75
S1436	6 x 30 CF	395	"Zeiss"	18.75
S1435	6 x 30 IF	395	"Zeiss"	16.75
S1438	7 x 35 CF	341	"Zeiss"	20.75
S1437	7 x 35 IF	341	"Zeiss"	17.95
S1771	7 x 35 CF	341	American	23.50
S1439	7 x 35 CF	578	American*	35.00
S2191	7 x 50 CF	530	American**	42.50
S1106	7 x 50 CF	372	"Zeiss"	24.95
S-961	7 x 50 IF	372	"Zeiss"	22.50
S1503	7 x 50 CF	372	American	32.50
S1443	8 x 30 CF	393	"Zeiss"	21.00
S1229	8 x 30 IF	393	"Zeiss"	18.25
S1108	10 x 50 IF	275	"Zeiss"	26.75
S1442	20 x 50 CF	183	"Zeiss"	33.75

*Wide-angle 11° **Wide-angle

Add 10% Federal tax to all prices above.

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Cat. No. S1576.....6 x 30..... **$10.00 ppd.**
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Cat. No. S1578.....7 x 35..... **12.50 ppd.**
Cat. No. S1303.....7 x 50..... **14.75 ppd.**
Cat. No. S1579.....16 x 50..... **17.50 ppd.**
Cat. No. S1580.....20 x 50..... **20.00 ppd.**

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NORTH POLE
NORTH GALACTIC POLE
DOUBLE CLUSTER
PLEIADES
ECLIPTIC
TAURUS
AURIGA
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GEMINI
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BIG DIPPER
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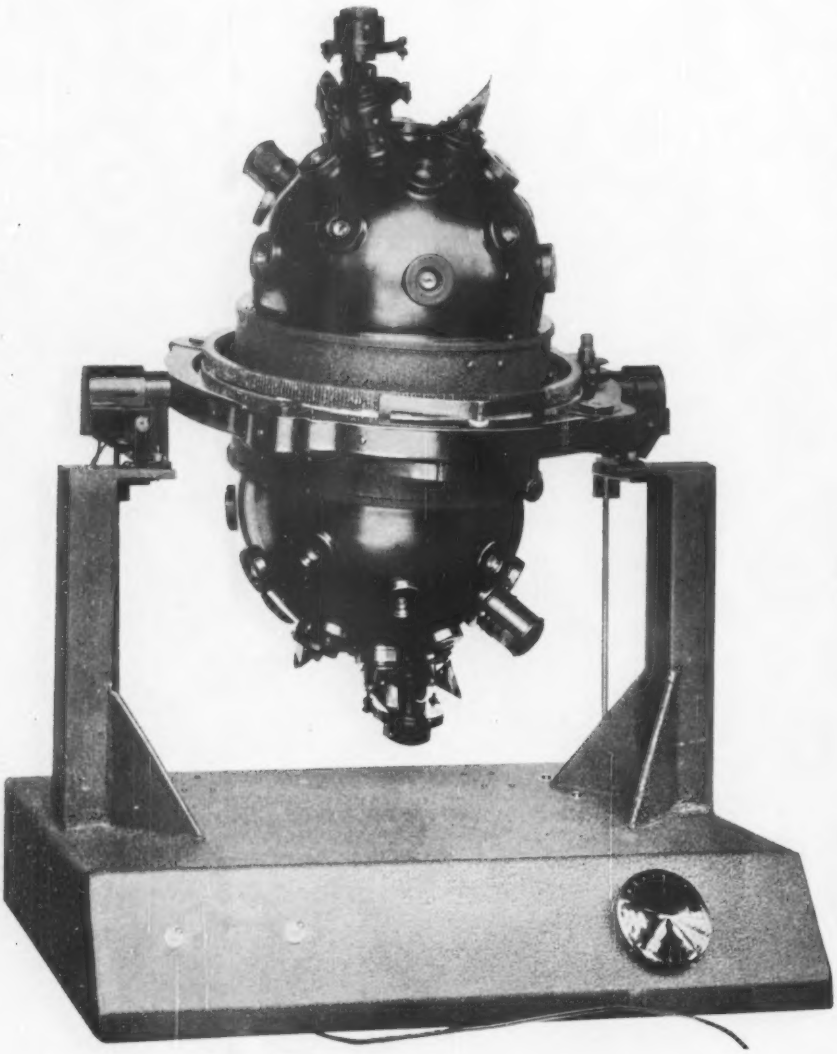

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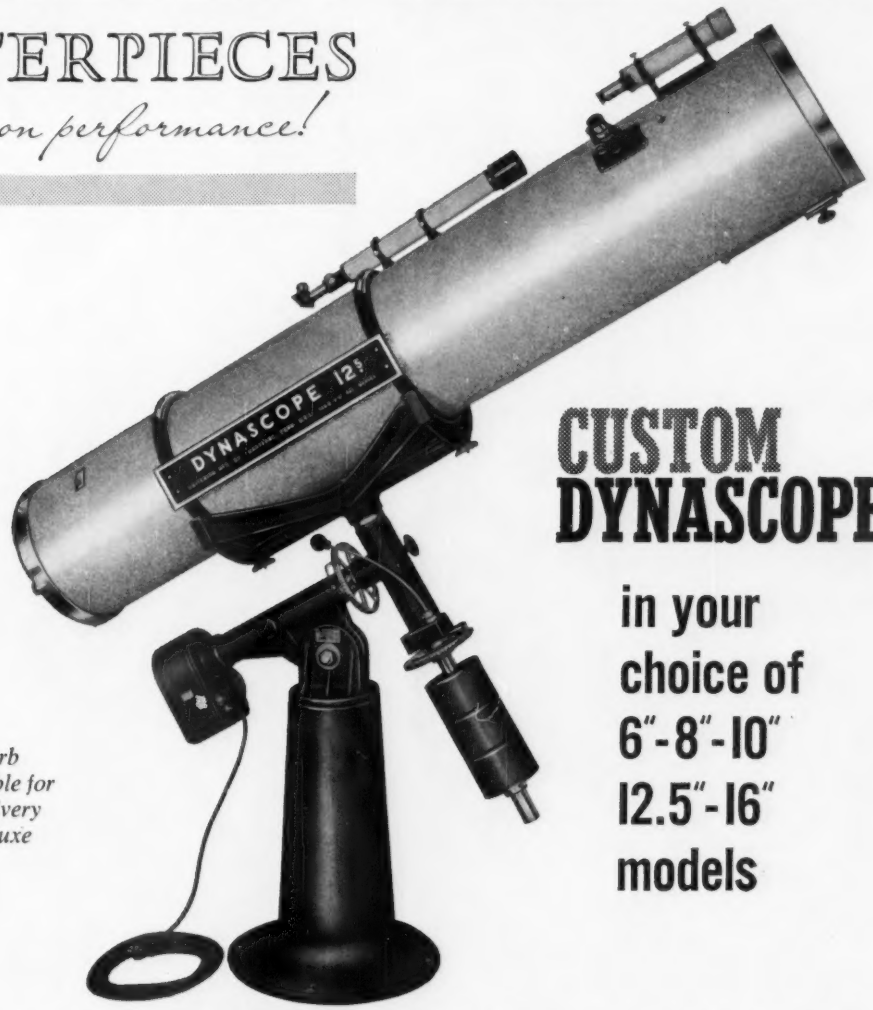

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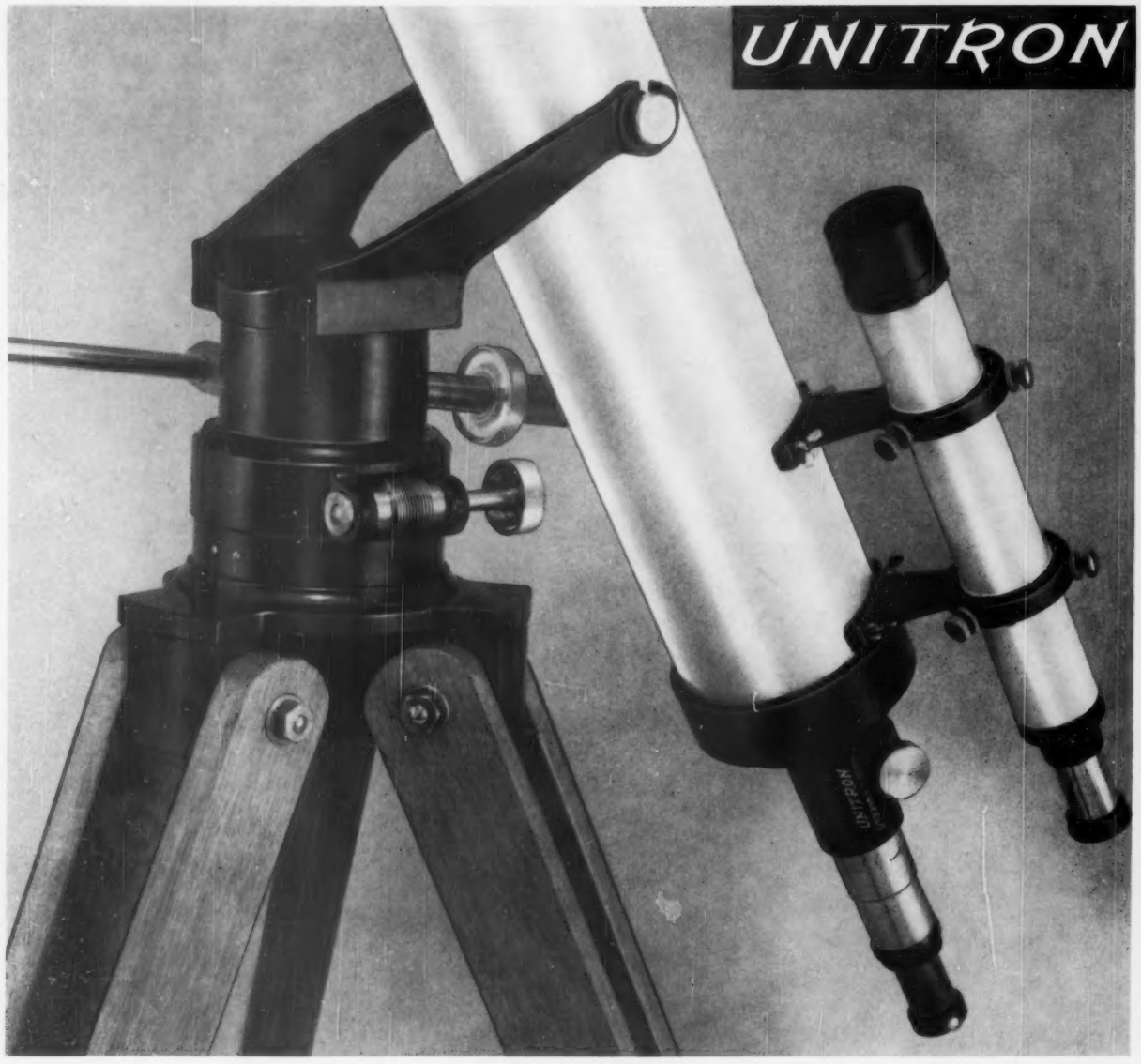

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See pages 240 and 241.

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